The SCIENTIFIC MONTHLY

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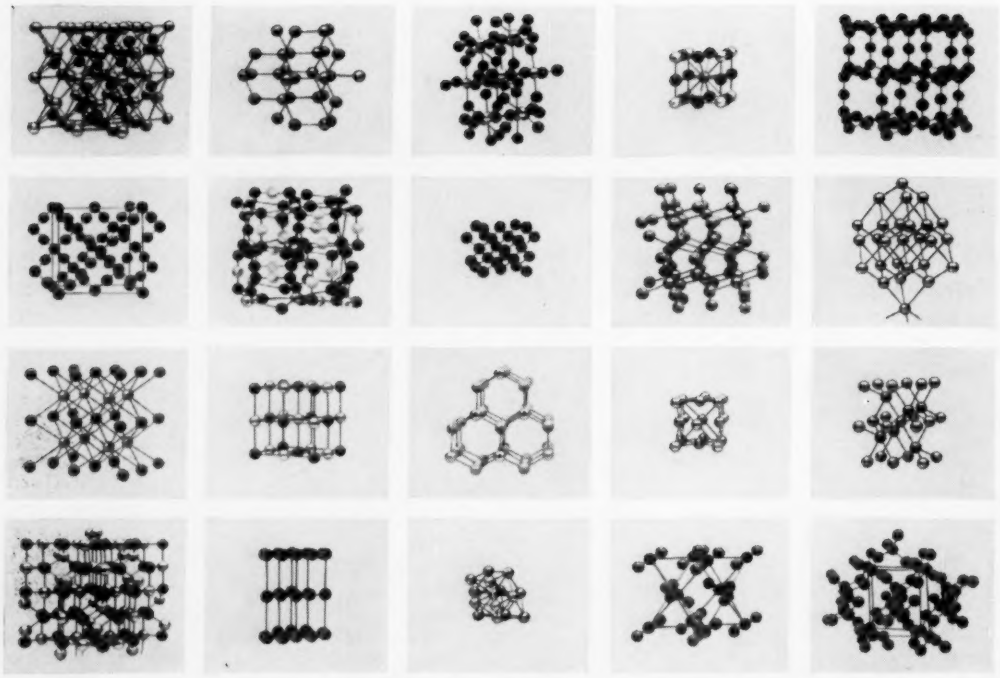

Crystal structure models. Top row, left to right: cuprite, zincblende, rutile, perovskite, tridymite. Second row: cristobalite, potassium dihydrogen phosphate, diamond, pyrites, arsenic. Third row: caesium chloride, sodium chloride, wurtzite, copper, niccolite. Fourth row: spinel, graphite, beryllium, carbon dioxide, alpha-quartz.

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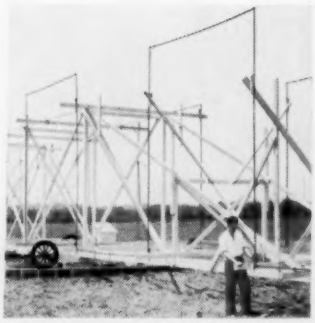

Directional antenna used by Karl G. Jansky in discovery of stellar radio signals at Bell Telephone Laboratories in 1932.

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[*Courtesy A. M. Winchester, Stetson University, see page 164*]

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Science and Technology

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Optical Design Kit

Nineteen components, including a prism; cylindrical and spherical lenses; and flat, cylindrical, and spherical mirrors are packed in an engineer's optical design kit. Components are suitable for use in all types of optical systems and devices. (Houston Technical Laboratories, Dept. SM, 2424 Branard, Houston 6, Tex.)

Gas Chromatograph

Kromo-Tog, an instrument for the analysis of gases and liquids by gas chromatography, has been announced by Burrell. The instrument provides all the basic instrumentation needed for analysis by the elution method. The volume of a gas sample required is ordinarily not more than 10 ml; the volume of a liquid sample required is usually less than 0.1 ml. Liquid samples must have 10 to 20 mm vapor pressure at the temperature of the analysis. The instrument includes a constant-temperature air bath, seven volume tubes, and helical heating coils. One- and two-column models are available. Booklet 83. (Burrell Corp., Dept. SM, 2223 Fifth Ave., Pittsburgh 19, Pa.)

Instrument Catalog

New instruments of various types are described in the 24th edition of "What's new for the laboratory," which is available on request. (Scientific Glass Apparatus Co., Inc., Dept. SM, 100 Lakewood Terrace, Bloomfield, N.J.)

Electronic Hygrometer

New humidity controller, the Humistat electronic hygrometer, automatically operates large or small humidifiers and air conditioners to maintain humidity control within ±1.25-percent relative humidity. The relative humidity range from 5 to 95 percent is covered by individual sensing elements with operating ranges of about 15-percent relative humidity. The instrument employs the Aminco-Dunmore electric hygrometer which is mounted inside the case. Bulletin 2273. (American Instrument Co., Inc., Dept. SM, Silver Spring, Md.)

Micromanipulator

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Multichannel Analyzer

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Analyzer

Components of light hydrocarbon gases under normal temperature and pressure can be separated, identified, collected, and measured by a new analyzer, the Fracton, which also records the analytic data. The instrument operates by the method of absorption fractionation. Operation is largely automatic. Booklet 82. (Burrell Corp., Dept. SM, 2223 Fifth Ave., Pittsburgh 19, Pa.)

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Twelve bulbs can be employed with a new spectral lamp for work throughout the spectrum. The 12 bulbs, cadmium, cesium, helium, mercury, mercury-cadmium, potassium, sodium, neon, rubidium, thallium, zinc, and a second mercury bulb with a window-like opening in the outer bulb for short-wave ultraviolet are used interchangeably in one auxiliary operating unit. The lamps are equipped with prefocus bases and identical light center lengths. (George W. Gates and Co., Inc., Dept. SM, Hempstead Turnpike and Lucille Ave., Franklin Square, N.Y.)

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THE SCIENTIFIC MONTHLY

MARCH 1956

History of Science and the Sociology of Science

HERBERT DINGLE

Dr. Dingle is professor of history and philosophy of science at University College, London, and president of the British Society for the History of Science. He is a former president of the Royal Astronomical Society.

HISTORY is everything that has happened. The writing of history is (or should be) the recording of history in such a way that the relationships between the events are seen as clearly as possible. In practice, this means a recording of the events in chronological sequence, for —at any rate, so far as present knowledge goes —the cause-and-effect relationship, according to which each event is the result of others in its past and is at least partly responsible for others in its future, is overwhelmingly the most satisfying means of exhibiting the dependence of one event on another. History, then—if the homely character of the simile may be pardoned—may be pictured as a cylinder of toothpaste issuing from a gigantic tube, each cross section representing all the events that occur at any one instant; the events are connected with each other and with those in the adjacent cross sections by cohesion, which represents the cause-and-effect relationship.

To write general history is humanly impossible. The events at each instant are so numerous, so various, and they are connected with one another by such complex routes that no human mind could grasp the direct chronological recital of the transition from one cross section to the next. We have to select particular types of events and follow their course through the time stream without more regard than is indispensable to events of other types. The result is what we call the history of this, that, or the other. If the selection is made properly (an extremely important proviso), general history will be obtained by putting together all such partial histories at the end. If it is not so obtained, then the selection has been made improperly.

When I was at school, the history that I was taught was mainly that of the English monarchy. In the reign of Richard II, for instance, there occurred a peasants' revolt, and the king on one occasion went out to meet the peasants and discuss the situation. For that reason, it was necessary to mention this revolt, but how it arose and what the outcome of it was I was not told. Those things had no perceptible relationship to the later difficulties of Richard that led to his deposition, and therefore they could be ignored in the history of that particular thread of events. Had the subject been English social history, the causes of the peasants' revolt and the social conditions that resulted from it would doubtless have been exhibited in intelligible order—had the knowledge been available—and Richard II would have appeared out of the blue to play his part in one brief incident and would then have returned into obscurity.

I am no historian and I venture no opinion on the question whether the English monarchy and

English social conditions are elements in the best analysis of events—that is, in the analysis that enables the subsequent synthesis to give the best representation of history as a whole. All that I would insist on is that some analysis is essential if any understanding at all of history is to be achieved. The criticism so often heard that such and such a treatment of history is invalid because the subject under consideration did not develop in isolation is a superficial and worthless criticism. Of course it didn't, but unless you consider it first as though it did and then consider how its development as a whole was related to the development of other things that have also been first treated in isolation, you will never, being human, learn anything at all. A part song is essentially a succession of chords, not single notes, but unless the conductor takes care that the trebles and altos and tenors confine themselves to their own isolated sequences, the result will be chaos. Say with Browning, if you like, that the whole song is more than the sum of the parts, that out of three sounds you frame not a fourth sound but a star. The fact remains that you will not get the star unless you first take the single notes and then put them together.

The important question is not Shall I analyze? but What analysis shall I make? The best analysis is likely to be that which provides threads showing the minimum of direct interference from adjacent ones. The (geologic) history of the earth is an example of a suitable one. Since the earth was formed, the only external influences on its development have been those of the other members of the solar system, of which the sun far transcends all the rest in importance. If the complete geologic history of the earth were written, the modification that would have to be made if we knew the whole course of evolution of the rest of the universe and the complete activities of man and the lower forms of life would, in all probability, be next to nothing.

On the other hand, a subject such as *criticism* or *freedom* is clearly unsuitable. The same critics have been extremely open-minded in criticism of painting and uncompromisingly opposed to criticism of the Scriptures, and the reasons for this are so intertwined with the histories of their political institutions, their personal upbringing, their genetic qualities, and so on that a history of criticism in general is not worth attempting. President Roosevelt enumerated four freedoms: we could add as many more as we pleased and still not exhaust the elements of this complex conception. At various times, men have been free to think as they liked provided that they did not speak as they liked; to speak as they liked provided that they did not act as they liked; to act as they liked provided that their actions did not interfere with other people; and so on. To attempt the history of freedom is to attempt the impossible (*1*).

The occasion of these general remarks is the appearance of a report in the *Proceedings of the American Philosophical Society* (*2*) of a conference that was held at Philadelphia in February 1955 to consider the need for education and research in the history, philosophy, and sociology of science, and in particular to consider how the National Science Foundation of the United States could assist in meeting this need. I was kindly invited to attend this conference, and I am very grateful for the opportunity thus afforded me of discussing the various questions involved with the leading thinkers on these subjects in America. Among the many questions raised was one that may be briefly stated as follows. Should the history of science be studied and taught as something inseparable from the social conditions obtaining at the various stages of its evolution, or should it be studied and taught in the first instance as the development of our understanding of the relationships between the various natural phenomena and *then* related to the social conditions that it affected and that affected it as its development went on? I considered that the latter was the proper course, and in his introduction to the report of the conference the chairman, Richard H. Shryock of Johns Hopkins University, selects this point for special consideration and implies (I think rightly) that the majority of the participants thought otherwise. He proceeds to give reasons why, if I understand him rightly, he also thinks otherwise. In view of the undoubted importance of the question, I would like to comment on the considerations he advances in the light of the general ideas I have outlined here.

Shryock—speaking as the voice of "some participants" but giving the impression (I trust I am not misrepresenting him) that he is among them—states that "social presuppositions or interests often insinuate themselves into what seem at first glance to be the most objective ideas of the investigator, with the result that it may be misleading to omit the role of environmental factors even in tracing ideas as such. . . . It is sometimes misleading to attempt any evaluation of ideas outside their social context." As an example, Shryock cites medical history in the 18th century. He states that medical men then seemed less scientific than physicists and astronomers and implies that this illusion was due to social factors. Hence, unless these factors are introduced into the story of the development of

ideas, physicians will seem to have been inherently less logical than physicists were. Moreover, social conditions were responsible for the facts that medical scientists, unlike physicists, "could only pursue research in the little time left over from their practice of an art," and that medicine, unlike physics or astronomy, "operated within a dense atmosphere of human hopes and fears." Consequently, we must conclude that "the outcome in a scientific field is often the result of a continuing interplay between ideas and their social environment."

Now I fully appreciate everything that Shryock wishes to urge in this connection, and if I differ from him at all it is merely in doubting whether a student who learns that William Herschel believed the sun to be an inhabited globe will be in danger of thinking that medical men of his time were inherently less scientific than astronomers. But I cannot help thinking that Shryock has missed the point, for nothing that he has said seems to me to bear on the question at issue.

In the first place, in taking medicine as his example he has made an invalid choice. Medicine is not a science—or, to save quarreling about words, let me say that it is not a subject of the same character as physics and astronomy or a subject whose history and philosophy are in question. Indeed, Shryock himself has called it "an art," but the important point about it in this context is that, unlike physics or astronomy, it is to begin with a social matter in itself. The existence of medicine presupposes that a "healthy" community is to be preferred to a "diseased" one; its object is to transform the latter into the former. From the scientific point of view, however, a healthy and a diseased body are simply two equally interesting forms of the same thing, like ammonium cyanate and urea, for instance, or graphite and diamond. No chemist, as a chemist, would dispute the point of precedency between graphite and diamond. If he wished to make a present to his wife, he would choose his carbon as diamond; if he wished to record immediately the masterpiece that had come into his head, he would prefer graphite. But neither choice is a scientific one, and for the same reason the preference for a healthy body over a diseased one is not a scientific one, and therefore medicine is not a science. It has, of course, a scientific element in its foundation—the physiological processes that go on in a living body—but what makes it medicine, and what determines its history as medicine, is precisely that superstructure which it owes to the social requirement that the community shall be as healthy as possible. It is therefore not to be expected that the study of medicine apart from social factors will be a profitable study, although hardly for the reason that Shryock gives. If it makes medical men, *as such*, appear less scientific than physicists or astronomers, it is to that extent justified, because that is exactly what they are.

But, leaving this particular example and returning to the general question, the whole force of Shryock's contention is directed away from the point at issue, which is not *whether* the interaction of social conditions with the development of science shall be studied, but *how* it shall be studied. And here science, as a development of ideas concerning the relationships between natural phenomena, presents itself as an almost ideal example of the isolable threads of history that are the most effective to choose for the attainment of ultimate understanding of the whole. Take any scientific law you like—Newton's laws of motion and gravitation, the laws of thermodynamics, the laws of chemical combination, the law of evolution, the laws of heredity—they are true or false apart altogether from any consideration of social conditions or anything else except the uncontrollable facts of nature and the unavoidable requirements of logical necessity. And not only what they are but, in a scarcely less complete sense, their course of development is independent of everything but uncontrollable necessity. Social needs, to which some writers would have us refer all scientific developments, have next to no influence. They may determine that one branch of science rather than another shall receive most attention at a particular time, but the result of that attention has nothing to do with them. No one had greater need of a radio set than Wellington at the Battle of Waterloo, but he could not have one because Marconi's experiments had not been made; and Marconi's experiments had not been made because Hertz' experiments had not been made; and Hertz' experiments had not been made because Maxwell's equations had not been formulated; and Maxwell's equations had not been formulated because Faraday's experiments had not been made; and so on and so on. These things had to happen, and could happen only in that order, before a radio set became possible, and that would have been true under feudalism or capitalism or socialism or communism or any other ism. These forms of social organization can at most affect the rate of progress, the place where the discoveries are made, and perhaps in very minor details the order in which they are made. On the main course of scientific development, their influence is nonexistent.

This being so, what conceivable advantage can

there be in obscuring such a clear thread of historical development by insisting on intruding social factors before the development is properly understood? On the other hand, when the historical development is properly understood, we are in the best possible position for understanding how social conditions did in some measure determine its rate and places of occurrence and how in much greater measure it influenced the course of development of social conditions. It is not at all a question of relative importance. If your interest is only in the laws of subhuman nature, you can study the history of our knowledge of that alone. If it is only in the history of social systems, you can take over from the historian of pure science all that is relevant to your purpose and leave the rest. If it is in both, you can understand their interaction far better by acquiring an independent knowledge of each than you can by studying *only* their interaction or by forcing them into an unnatural union.

This danger of an unnatural union is not an imaginary one; it is only too actual. The first conspicuous modern intrusion of irrelevant social factors into the development of science was probably that which occurred in Nazi Germany during the 1930's. The theory then advanced was that the character of a scientific development was largely determined by the race of the person to whom it was due. For instance, there was said to be a recognizable difference between Jewish mathematics and physics and those of the Nordic races, and the main features of this difference were identified and described (*3*). This idea is not very active today. Being socially originated, it was socially destroyed in the late war, and physics and mathematics go on developing as though it had never been. I suppose that if we are to regard scientific and social developments as inseparable even in thought, the details of this episode should find a place in the history of physical science, but I cannot think that it would throw any real light on that history.

An idea more alive at the present time is that scientific laws are the result of social necessities and reflect the social organization of the community within which they arise. Thus, J. D. Bernal, in a recent much-popularized book (*4*), writes: "Newton's theory of inertia came from the prevailing rational interpretation of religion, and Darwin's natural selection from the current conception of the natural justice of free competition." Presumably inertia was not shown by material bodies in India, and natural selection is not now operative in the Soviet Union. These ideas, ludicrous as they appear and are, are nevertheless held by no inconsiderable number of scientists and others of repute. That they are the direct result of trying to relate scientific discoveries to social conditions without a preliminary recognition of the significance of those discoveries may be seen immediately from the fact that Newton's theory of inertia and Darwin's natural selection stand or fall by facts such as those marshaled in the *Principia* and the *Origin of Species,* and these are quite independent of the prevailing 17th century English interpretation of religion and any considerations at all of justice. I do not believe that such nonsense could have been written if science had been understood first in terms of the evidence on which it rests and afterward studied in relation to the social conditions in which it developed.

There is indeed a wider aspect of this matter. If you insist that science shall not be taught or studied independently of the circumstances in which it came to light, you cannot prevent the evasion of a purely scientific argument by the intrusion of almost any kind of irrelevancy. Some years ago I was involved in a controversy with a well-known physicist on the question whether (according to the theory of relativity, which we both accepted) the Fitzgerald-Lorentz contraction was of the same character as "the variations [of length] that are produced by changes of temperature." I maintained that it was not, he maintained that it was. I put forward the following argument. If, of two rods that are equal in length when at rest, one is in relative motion with respect to the other, you can choose which is the one that has suffered the "contraction" by choosing your frame of reference accordingly. If, however, of two rods that are equal in length at the same temperature, one is colder than the other, it is that one only that must be said to have contracted, no matter how you choose your frame of reference or your scale of temperature measurement. Hence the contraction caused by change of temperature is of a different character from that caused by change of motion (*5*).

I was simple enough to suppose that this was a purely impersonal argument that could be dealt with in purely physical terms. My controversialist, however, offered no reply in such terms, but referred to "the solution of the whole mystery, which turns out to be not a problem of physics but of Professor Dingle's psychology." My psychology was then discussed, but no answer to the physical argument was given. It is no doubt very flattering to me that such an important point in physical theory should depend on my mental characteristics, but I have not been able to derive the pleasure from this that I ought because I cannot persuade myself that the question would not remain exactly the same if I were quite other than I am or even if I had never been born. I grant, however, that that inability may be a matter of my psychology.

Finally the matter was referred to another well-

known physicist for summing up. He did so at length, but the simple argument that I had advanced was again completely avoided. His concluding paragraphs contained the following passages: "I do not believe that this decision can be made on the plane of logical arguments. . . . I see (rightly or wrongly) in this difference of opinions an instance of two different philosophic views known under the names of *realism* and *idealism*. . . . But I do not see how I could convince someone of this by logical arguments. I am very much afraid that in arguing my case I would have to fight the philosophy of idealism and I would have to show that idealism leads to a social attitude which I regard as wrong."

There the matter ended. My argument was never faced, and though I have remained, and still remain, open to receive enlightenment on the matter, it has been avoided like a plague ever since. And so it appears that the question whether the Fitzgerald-Lorentz contraction is identical in character with the contraction produced by cooling cannot be settled in physical terms. Psychology and social attitudes belong to the essence of it. Today the answer might be that the two things are of different kinds, but when a physicist with a different psychology and a different social attitude turns his attention to it, it will become clear that they are identical in character, and a physical advance will have been made. These are the views not of morons but of physicists of great distinction. They show the sort of thing that can pass without protest now that we have realized the importance of interpreting a discovery always in terms of the extraneous conditions in which it arose.

I do not see how such incidents as this—which I feel sure that Shryock deplores as deeply as I do—can be prevented from reproducing themselves without limit as long as we insist that the history of science shall be regarded as inseparable from the history of the social conditions that accompanied it. Let me repeat that it is not at all a matter of the relative importance of the two disciplines; that is not in question. Undoubtedly they are both highly important, and equally important is the subsequent task of bringing them into relationship with one another. But I am convinced that unless we insist in the clearest possible terms that they are as distinct from one another as two fragments of a single universe can possibly be, and unless we present scientific facts and theories first of all in terms of the actual evidence on which they rest, which in the great majority of sciences has nothing to do with the time, place, and circumstances of their discovery or invention, we are smoothing the path for illusions and evasions that will have the gravest consequences for the future.

I regard this matter as one of vital importance.

References and Notes

1. Of course, in a limited context and for a particular purpose, it may be desirable to consider some such history as this. I am speaking of it only as an effective constituent of an analysis of general history.
2. *Proc. Am. Phil. Soc.* **99**, No. 5, 325 (1955).
3. References are perhaps hardly necessary for so well-known a phenomenon, but I might quote the handiest. According to Lenard, "We must recognize that it is unworthy of a German to be the intellectual follower of a Jew. Natural science, properly so called, is of completely Aryan origin." Quoted by P. Frank, *Einstein: His Life and Times* (*Knopf, New York,* 1947), p. 280.
4. J. D. Bernal, *Science in History* (Watts, London, 1954), p. 28.
5. *Am. J. Phys.* **10**, 1, 203, 205, (1942); **11**, 228, 219 (1943).

And generally let every student of nature take this as a rule—that whatever his mind seizes and dwells upon with peculiar satisfaction is to be held in suspicion, and that so much the more care is to be taken in dealing with such questions to keep the understanding even and clear.—FRANCIS BACON, 1561–1626.

Meaninglessness of the Word Protoplasm

GARRETT HARDIN

Dr. Hardin spent the first 10 years of his scientific career as a microbiologist, first at Stanford University, then with the Carnegie Institution of Washington. Beginning with his acceptance of a position on the staff of Santa Barbara College in 1946, his major efforts have shifted to teaching and the analytic evaluation of basic biological concepts and their human implications.

IT is perhaps more foolhardy than courageous to assert that an almost universally used term is meaningless. Yet such an assertion I make here. I believe that a careful consideration of the term *protoplasm* will convince the unprejudiced judge that its various assigned meanings are so contradictory and have such uncertain reference to facts that to call the term meaningless is no more than an act of simple charity. But before taking up the argument, let us examine some statements using this term, as culled from representative biology textbooks (*1*) published in the last 20 years.

1) Protoplasm has been aptly called *life stuff*, for life cannot exist without it.
2) The material inside the alga is nothing less than "protoplasm," the essential living substance.
3) Protoplasm is the physical basis of life, the common substance shared by all forms of life—the substance in which all reactions of a living body have their origin.
4) Purkinje was the first to make use of the term *protoplasm* for living matter, but the term was not in general use until Max Schulze, about 1861, demonstrated that the sarcode of animal cells and the protoplasm of plant cells were one and the same thing.
5) The living material contained within the walls of these cells is termed "protoplasm." All life is composed of this substance. It *is* life!
6) Protoplasm is a mixture of many kinds of substances.
7) Cat protoplasm and dog protoplasm are not alike; protoplasm of the corn leaf differs from the protoplasm of the oak leaf; indeed the protoplasm in different parts of the same organism differs to some extent. . . . For example, the protoplasm of a liver cell is different from that of a muscle. Yet, in spite of this, the fundamental nature of all kinds of protoplasm is the same.

In passing, we should note incompatibilities among these various statements: protoplasm is now a substance, now a mixture of substances; sometimes it is an entity common to all organisms, but on the other hand "it" is different in all organisms, even in different tissues of a single organism.

Were we faced with a simple factual problem, we could demand uniform, correct statements of the authors. But our problem is no such simple one. Rather, we are faced with more subtle matters connected with the foundations of biology, with the primitive conceptual frameworks that govern our thinking about "life." I hope to show that the conceptual framework implicit in the word *protoplasm* is worse than vague; it is bad. At best, the word has functioned only as window dressing; at worst, it has probably impeded scientific progress. It can further be shown that those research workers who are most actively engaged in determining the facts to which *protoplasm* supposedly refers have the least use for the term—surely a significant rejoinder to anyone who would suggest that the concept is a "useful fiction," in Vaihinger's sense (*2*).

In advance, let me disclaim originality. Most of what follows, if original at all, is original only in organization and explicitness. There have been many biologists who have for years acted as if *protoplasm* were a meaningless term—although not all of them were explicitly aware of their attitude. But there was one such man, the great biochemist Frederick Gowland Hopkins, who was quite conscious of his attitude toward *protoplasm*; so I shall draw considerably upon his writings (*3*). I believe, however, that the fundamental issues can be perceived more clearly if we examine advances made in quite a different field of human endeavor, the field of comparative linguistics. The relevant insights have been beautifully stated by a remarkable amateur, Benjamin Lee Whorf. On no occasion (so far as I know) did Whorf concern himself with the word *protoplasm*; but his analysis of the meaning of other, similar words enables us more easily to escape from the tyranny of this one.

Hopkins and Protoplasm

Probably no one man has been more influential in determining the basic conceptual frameworks of modern biochemistry than Frederick Gowland Hopkins (Fig. 1). Himself a Nobel prize winner (1929), he trained a whole generation of leaders in research, among whom are included at least 75 holders of professional chairs, 24 fellows of the Royal Society, and 3 Nobel laureates. When reading over the old papers of Hopkins, one is continually delighted at discovering the earliest expression of concepts and points of view that are now platitudinous in biological thinking. But these concepts were established only in the face of considerable opposition from the old guard of scientists, rallying around the banner of *protoplasm*. One very distinguished organic chemist of the 1880's, on being told of Hopkins' ambition to elucidate the chemistry of living organisms, remonstrated (*3*, p. 245): "The chemistry of the living? That is the chemistry of protoplasm: That is super-chemistry; seek, my young friend, for other ambitions." As Hopkins remarked, in his address to the British Association in 1933, such an attitude, widely prevalent at the beginning of his career, was "almost as inhibitory to productive chemical thought and study as any of the claims of vitalism" (*3*, p. 244).

In *protoplasm* we are faced with a most insidious danger in intellectual endeavors, the danger of words that are too powerful, that "explain" everything. Such enemies of thought, like all enemies, may be easier to spot if we label them. Such "explain-alls" need a name. As we borrow from the Greek to call a "cure-all" a *panacea*, so let us christen an "explain-all" a *panchreston*. The history of science is littered with the carcasses of discarded panchrestons: the Galenic *humours*, the Bergsonian *élan vital*, and the Drieschian *entelechy* are a few biological cases in point. A panchreston, which "explains" all, *explains* nothing.

Hopkins saw this, and recognized *protoplasm* as such a panchreston. Almost alone in the scientific world, he rejected this tempting crutch and set out to explain the phenomena of biology in an elemental way. We may suppose that at first he was not too clear in his own mind regarding the tendency of his research, but by 1913, when he delivered his famous address, "The dynamic side of biochemistry," to the British Association, he was able to chart firmly the outlines of the new world of biological thinking. Hopkins said (*3*, p. 137):

> My main thesis will be that *in the study of the intermediate processes of metabolism we have to deal, not with complex substances which elude ordinary chemical methods, but with simple substances undergoing comprehensible reactions.* By simple substances I mean such as are of easily ascertainable structure and of a molecular weight within a range to which the organic chemist is well accustomed. I intend also to emphasize the fact that it is *not alone with the separation and identification of products from the animal that our present studies deal; but with their reactions in the body; with the dynamic side of biochemical phenomena.*

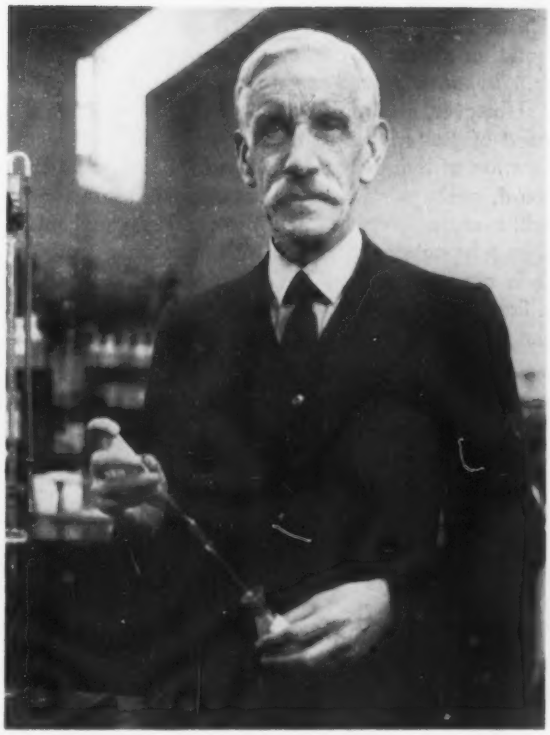

Fig. 1. The great English biochemist Frederick Gowland Hopkins (1861–1947) who, though initiating researches that threw great light on the nature of life, regarded the term *protoplasm* as an impediment to thinking. [Courtesy Ramsay & Muspratt, Cambridge, England]

That which Hopkins has italicized in the foregoing paragraph is a commonplace of thought and action today, but this is so largely because of his work and influence. The working hypothesis that metabolism consists of very simple chemical reactions (however complexly interrelated) has proved to be *the* fruitful hypothesis of 20th-century biochemistry, as witness the complex, but clearly describable, metabolic scheme of the chemical pathways now known to be involved in the "ornithine cycle" (*4*). With few exceptions ("spontaneous reactions"), each of the arrows shown in Fig. 2 stands for a reaction brought about by a specific enzyme. We should, then, picture a similar network of enzymes underlying, so to speak, the dia-

gramed network of substances and reactions. And *where,* in all this web, *is protoplasm?* To paraphrase Laplace's classic reply to Napoleon's famous question about an earlier panchreston, *That, sire, is a hypothesis we have no need of* (*5*).

However, although we may feel that we have no need of *protoplasm* at certain stages of our investigation of living matter, is it not possible that this word, perhaps with more sophisticated overtones, will eventually creep back into the biological fold? The scheme shown in Fig. 2 is not an organism; it is abstracted from an organism—or, more significantly, from many organisms— for it has turned out that however various the many species of plants and animals may be in appearance, they are, biochemically, truly "brothers under the skin."

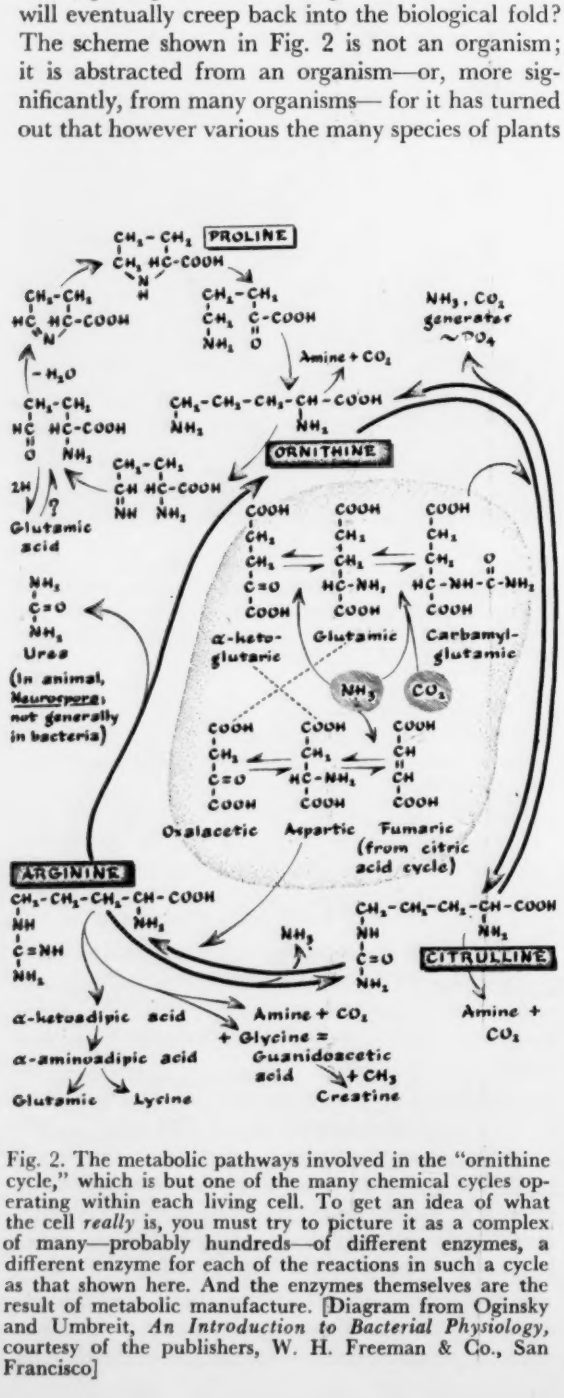

Fig. 2. The metabolic pathways involved in the "ornithine cycle," which is but one of the many chemical cycles operating within each living cell. To get an idea of what the cell *really* is, you must try to picture it as a complex of many—probably hundreds—of different enzymes, a different enzyme for each of the reactions in such a cycle as that shown here. And the enzymes themselves are the result of metabolic manufacture. [Diagram from Oginsky and Umbreit, *An Introduction to Bacterial Physiology,* courtesy of the publishers, W. H. Freeman & Co., San Francisco]

As a working hypothesis—and a bit more, probably—we now hold that all organisms depend on a basic set of metabolic reactions. Each elementary reaction is brought about by a specific enzyme. The similarity of reactions therefore implies similar complements of enzymes in all, or almost all, organisms. Is this not the sort of unity that men were striving to express when they invented and developed the concept of protoplasm? Granted, there is no single substance to which we can attach this name. But is there not a *set* of substances that deserves the name, a constant, definable set that is unitary in whatever sense a set may be unitary? This is a tempting exegesis—sufficiently tempting, at any rate, that I, for one (*6*), have in the past resorted to it. I think now, however, that such a reinterpretation of the classic term *protoplasm* reintroduces an error of the most fundamental sort into biological thinking.

The error is a subtle one and, for this reason, is most easily attacked by subtle means. More is involved than bare biological facts; the basic structure of our language is involved. "Does protoplasm exist?" Such a question cannot be answered without first asking, "What does the question 'Does protoplasm exist?' mean?" What does it mean when we give a name to something? And what is a *thing*? These questions sound like the prelude to a deep treatise in ontology, but fortunately they are not. Fortunately for us mere scientists, the issues have been made very clear in recent years by some interesting and exciting studies in the field of linguistics, which is much easier to understand than ontology.

Whorf and Substantives

Anyone who has really learned a foreign language knows that some thoughts can be more readily expressed in one language than in another. The comparative study of any two languages will reveal some points of view that are built into one language, so to speak, but not into the other. I believe it was William James who pointed out, half a century ago, that French, Spanish, and German all make a distinction between two kinds of *knowing,* one by acquaintanceship, the other by understanding. Thus we have the French *connaître* and *savoir,* the Spanish *conocer* and *saber,* and the German *kennen* and *wissen.* But we who speak English must struggle along with the single verb *know,* making the distinction as best we can by hanging adverbs and modifying phrases onto the verb. The distinction can be made, but it is not built into the language, and since the speaker is not forced to choose between the two meanings

each time he selects his verb he may well lose sight of the difference.

We find a more poignant example of the restrictive aspects of idiom in the emotional reactions to old age incorporated in various languages. The meaning of the French *vieillard,* the Spanish *viejo,* and the German *Alte*—all terms implying respect and affection—is certainly inadequately represented by the English *old man,* which implies the decrepit rather than the venerable. Do we have such a poor opinion of old age because we have no simple honorific words for it? Or do we have no words for this status because we do not honor it? Probably a bit of both. We are faced here with a vicious circle of attitudes and words, the breaking of which is essential to a successful program of social geriatrics.

So far I have mentioned only ways in which English is inferior to other languages. Lest it be thought that this is always so or that these remarks are motivated by the reverse of ethnocentrism ("ethnoperipheralism"?), let us recall that the Frenchman's *chez nous* seems very lacking in the emotional warmth of the English *home.* And Bronowski (*7*) has told us of his delight, when learning English, at finding the active verb *like* (as well as *love*), where other European languages have to make a single verb do for both of the ideas of liking and loving.

But these examples, interesting as they are, scarcely hint at the profound differences that exist between the speech and thought of peoples of diverse culture and history. The Indo-European languages are basically alike in their structure and in the thought patterns they mirror. When one language lacks an exactly equivalent word for a word in another, it is usually possible—although it may require considerable art—to string several words together to closely approximate the meaning desired. But when we come to study the languages of the South Pacific, or of the American Indians, we discover that it is, in general, *not possible to translate from them into an Indo-European language, or vice versa.* This discovery was not easily made, we may be sure. It took a great deal of stumbling before anthropologists, ethnologists, and linguists realized the magnitude of the problem they faced —understanding other peoples *through understanding ourselves.* Travelers trying to understand "strange" languages by comparing them with "normal" languages (their own, of course), deafly passed by a new world of human understanding. Only when the unconscious working hypothesis of the normality of our tongue was abandoned was genuine progress made. And the most astonishing part of this progress was the insight it gave into the structure of our own language, into the form of our very thoughts. Out of the work of such men as Sapir, Malinowski, and Whorf, have emerged two very important generalizations about man and his languages: (i) Every word is a hypothesis about the nature of the world, and every sentence is a complex of hypotheses. (ii) We can think only those thoughts that our language permits us to think.

Fig. 3. Benjamin Lee Whorf (1897–41) a remarkable amateur in the field of linguistics, whose work has thrown great light on patterns of thinking among European men. [Courtesy John Haley, Hartford, Conn.]

These are clearly far-reaching generalizations. Are they true? Can we demonstrate their truth? At first sight, the second generalization would appear to be, by its nature, an irrefragable, an undemonstrable proposition—like knowledge of the simultaneous position and velocity of an electron, or the color of a photographic emulsion before it is exposed to light. Our situation is not quite hopeless, however; or, to put it another way, the second generalization is rather too extremely stated. Nevertheless, it calls our attention to some very important and subtle interrelationships of language and reality, relationships that have been made clear by the work of Benjamin Lee Whorf (Fig. 3).

In linguistics, Whorf (*8*) was an *amateur,* in the strict and noble sense of the word—that is, he was a *lover* of the subject. A graduate of the Massachusetts Institute of Technology, he was employed, until his death in 1941, by a fire insurance company as an expert in industrial fires and their prevention. In his spare time he took up the study of American

Indian languages, mastering several and shortly establishing himself as a recognized expert among professionals. In the process of learning Indian languages he necessarily had to look critically at his own language and its relation to reality. Some of the most important of the insights so gained are to be found in two beautiful papers, "Science and linguistics" (*9*) and "Languages and logic" (*10*), from which the following analysis is abstracted.

There is no one-to-one correspondence between language and the world. This is easy to say but hard to accept. What does it mean? By way of illustration, we begin by considering the basic structure of the Indo-European languages, which assume that everything that happens in the world can be properly described by

a substantive———a verb

which implicitly means that every phenomenon in nature is describable in terms of

an object———an action

or

an actor———an action

Such an analysis of the world seems self-evidently true to us—but only because we speak (and think) Indo-European. If there were a necessary one-to-one relationship between world and language, then the isolates of experience that we incorporate in the first part (the substantive) of this bipolarization in one language should be findable in all others, and the same would be true for the second part (the verb).

But this is not so. In the Hopi language *verbs* are used to indicate many things that we represent by nouns: lightning, wave, flame, meteor, puff of smoke, and pulsation. Note how very difficult it is even to describe one language in terms of another: in the preceding sentence, the very use of the word *things,* unavoidable in Indo-European, is false to the *meaning* of the sentence. We must somehow transcend our language in imagination to conceive this world in which our "things" have become *actions.*

We may ask, on what basis is an entity (perhaps a more neutral word than *thing*) assigned to the noun-pole or to the verb-pole? At first sight, it would seem that the assignment is made in Indo-European on the basis of duration: long-lasting—noun; short-lasting—verb. *House, man,* and *tree* are nouns; *hit, run,* and *tremble* are verbs. But then why is *fist* a noun? It is clearly a temporary entity. And what about *lightning, wave, flame,* and those other afore-mentioned entities that the Hopi regard as verbs—how can we justify assigning them to the noun-pole? And, by contrast, why are *possess* and *adhere* verbs, when they imply long duration, whereas *equilibrium* and *current* are nouns? And how does it happen that we use nouns to indicate relationships (such as sister or any other form of kinship), and nation, tribe, or any other societalship? The visiting Martian with a strict operationalist point of view would soon tell us that he could recognize a "sister" only by observing (or accepting the records of) two birth-actions (verbs, surely), and could recognize a society only by a complex of describable actions (verbs again) of its members. There is no such *thing* as a sister, or a nation—except as our grammar says there is. Other grammars say otherwise.

We have bipolarized nature and, for the most part, successfully—if we judge success by lack of overt signs of conflict. There is, however, one small but revealing sign of the strain we have put on language, and that is the little word *it*. There are some aspects of nature that lend themselves so poorly to bipolarization that we have to resort to this meaningless word to save our grammar. We say, "it rains," or "it thunders." But what, in heaven or on earth, is *it*? If *it* is anything at all it is surely the same thing as the verb: rain rains, thunder thunders. But what else can rain or thunder do? Are there both object and action, separately conceivable? Clearly not. The Hopi recognize this by using only one word where we use two. Actor and action are one.

The issue involved is much more than merely idiomatic. We see the world the way our language tells us to. Indo-European languages implicitly assert, as an overriding hypothesis, that everything in the world that can be talked about consists of both actor and action, of substantive and verb. So, when we see a flash in the summer sky, we say "lightning flashes"—substantive, verb; actor, action. Similarly, the unconscious assumption of a bipolarized world led Newtonian physicists to postulate the "ether" of space. Physicists were confronted with an action that appeared to be wave motion or undulation. "Common sense" (read, "language-generated thought patterns") said that there could be no action without an actor, so *ether* was invented to stand as the subject of the verb *to undulate.* It took an Einstein to escape from this tyranny of language. The problem was not, basically, one of physics at all; nor, perhaps, should we even call it a problem in metaphysics. It would seem more meaningful to call the ether puzzle a problem in *metalinguistics,* using a term coined by George L. Trager (*11*). Are all metaphysical problems, at bottom, only metalinguistic problems? Time will tell.

Protoplasm Revisited

Whitehead has remarked (*12*) that "It is harder to discover the elements than to develop the sci-

ence." Biology furnishes an excellent example of the truth of this trenchant remark. Certainly when we ask "What is life?" we intend to get at the elements of this science, but progress made in this direction has been slight as compared with the extensive development of the science in terms of describing hundreds of thousands of species or originating new strains of domesticated plants and animals. The development of our concept of what a living organism really *is*, is an interesting topic in the history of ideas that is yet to be written. Writing it will not be easy; the literature is voluminous and diffuse, and ideas are more implicit than explicit. Lacking such a thoroughgoing research, we must rely on the impressions of biologists who have lived through part of the last century of scientific discovery. An approximate account of this development has been given by Rudolph Schoenheimer (*13*), whose path we follow here.

The 19th century and the first part of the 20th were dominated by the view that the organism is essentially a combustion engine, a static structure into which one pours the fuel we call food, this fuel being then operated upon by the structure we call the living organism, which somehow "extracts" energy from the fuel, expelling waste materials through the exhaust ports. This picture is often credited to the German physicist and biologist Helmholtz and, no doubt, rightly in a sense; but we should now point out that the viewpoint is implicit in the structure of our language. We can hardly avoid thinking of a subject that does things, and this subject we may name variously—as interest dictates—the individual, the organism, the body, or *protoplasm*. And the action that the subject carries out is, simply put, metabolism.

With ever finer analytic research, particularly as the 20th century approached, some data were gathered that called for modifications in the Helmholtzian picture, although at first these were made only in a very minor way. The work of Folin and Rubner indicated that there was a surprising amount of destruction of what one would regard as the structure of a body, that a surprising amount of wear and tear seemed to be normal. Consequently, it appeared that not all of the energy-rich substances that were added to the fuel line of the organism were used strictly as fuel. Some of the "fuel," biochemists of the time said, was broken down for the sake of the energy that it could liberate, and a smaller fraction of it was employed in repairing the structure of the organism. From this type of analysis there arose the concepts of "endogenous metabolism" and "exogenous metabolism." Both of these concepts, be it noted, clearly imply a bipolarization of reality into an actor and an action, a substantive and a verb.

With the further development of biochemistry—and the trail here surely must be an intricate one but one very much in need of being rediscovered and marked—the Helmholtz-Rubner picture broke down. The more closely biochemists studied living organisms, the more difficult it was to tell the difference between the organism and its fuel, between endogenous and exogenous reactions, between assimilative and dissimilative reactions, between anabolic and catabolic reactions. When we have worked out this chapter in the history of ideas, we shall probably find that by the middle 1920's, or by 1930 at the latest, leading workers had abandoned the bipolarization of "livingness" in their own thinking (*14*).

The bipolar pairs of terms mentioned here initially appeared to be both natural and useful; in the end they turned out to have little connection with the real world. The factual situation began to become exceptionally clear when tracer isotopes of the elements most important in living organisms became available. With these, it became possible to follow the detailed movements of chemical substances in the living organisms. The results of tracer studies carried out in the 1930's and 1940's unambiguously destroyed the supports of the Helmholtzian edifice. The unquestionable essentiality of the proteins had led us to picture the organism as some sort of proteinaceous structure that operates on the foodstuffs passing through it. But we now know that the "structural" materials are among the most unstable parts of a cell: in the rat liver, for example, half of the protein is replaced every 6 days.

If we look again at Fig. 2 we realize that we can never expect to draw around the vortex of chemical changes represented some sort of stable structure in which these changes are taking place, for the "structures" responsible for bringing about these changes (enzymes and other proteins) are themselves part of vortices of chemical reactions. And there is continuous interchange of parts, for example, of the amino acids, between the vortices already known (like the one shown) and the vortices yet to be described, which we call "structural." Flatly, we must say that it is not proper to bipolarize the organism into structure and metabolic materials. As Schoenheimer (*13*, p. 65) has said:

> The new results imply that not only the fuel but the structural material is in a steady state of flux. The classical picture must thus be replaced by one which takes account of the dynamic state of body structure.
>
> A simple analogy, which may be taken as an incomplete illustration of this concept of living matter, can be drawn from a military regiment. A body of this type resembles a living adult organism in more than one respect. Its size fluctuates only

within narrow limits, and it has a well-defined, highly organized structure. On the other hand, the individuals of which it is composed are continually changing. Men join up, are transferred from post to post, are promoted or broken, and ultimately leave after varying lengths of service. The incoming and outgoing streams of men are numerically equal but they differ in composition. Recruits may be likened to the diet; the retirement and death correspond to excretion.

This analogy is necessarily imperfect as it relates to only certain aspects of the dynamic state of biological structure. While it depicts the continual replacement of structural units, it takes no account of their chemical interactions.

The organism is, then, not a "thing," but an "open system," as Bertalanffy (*15*) has repeatedly stressed. To say this is not simply to replace one term by another. The "grammar" of the terms is so different that such a replacement completely alters the meaning and validity of the sentences (*16*) in which they are used. In retrospect, we see, as Mainx (*17*) has said, that "The 'thinghood' of a living being is only a psychological experience of the human observer." As such, it has no more reality than the "coldness" we are all capable of feeling, which physics no longer has any use for. And just as we may, at certain levels of approximation, continue to speak of "heat" and "cold" instead of "amount of heat," so we may continue, in many situations, to speak of "structure" and "function," and of "the living thing," and its "environment," although we recognize that, strictly speaking, an organism is not a thing but *a place where* certain highly interesting processes are taking place.

With these insights we see, then, that the term *protoplasm* implies a view of livingness that is no longer tenable. Whatever this protean term refers to, it must imply a structure in a bipolarized picture of livingness. Clearly, functions are involved in this state—we need the verb *to metabolize*, or its equivalent. But do we need a noun, a substantive, to act as the subject of the verb? We doubt it, once we note the inner parallelism of these sentences: "Lightning flashes." "Ether undulates." "Protoplasm metabolizes." Find the lightning that flashes and the ether that undulates and then, perhaps, we will see how to find the protoplasm that metabolizes.

Envoi: the Deathbed of Protoplasm?

If *protoplasm* is really useless, or detrimental, to thinking, then we should be able to show that the

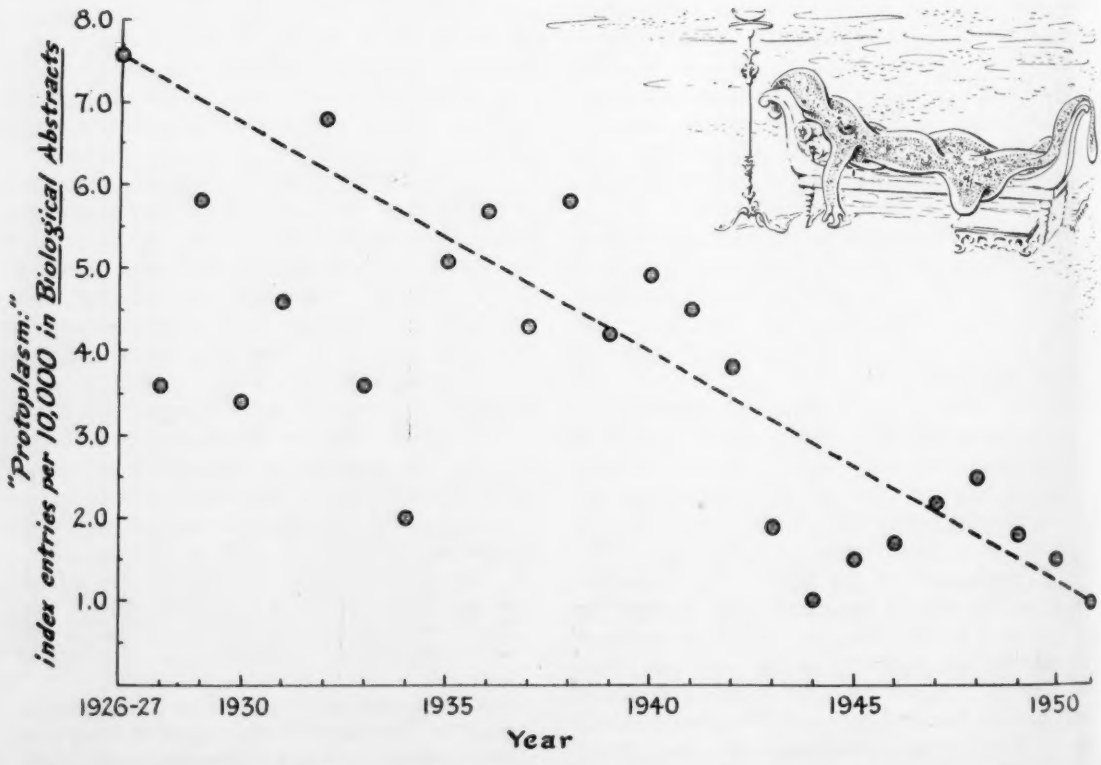

Fig. 4. "Protoplasm" on its deathbed, as indicated by the decline in the frequency with which the term is indexed in *Biological Abstracts*. [Drawing by Evan Gillespie]

word is being used increasingly less often by those engaged in thinking and research. With this in mind I examined the indexes of *Biological Abstracts* for the 25-year period 1926–51, counting the number of entries under "protoplasm" (including "viscosity of protoplasm"). I estimated the total number of entries in the index, which should be a rough measure to total research productivity, and then calculated the number of entries under "protoplasm" per 10,000 index entries. The resulting figures are graphed in Fig. 4. Note that the relative frequency of "protoplasm" entries falls irregularly throughout this period, descending especially steeply after 1942. By 1951 the relative frequency of entries under "protoplasm" had decreased by 88 percent from the level of 1926. Does this mean that biologists are no longer concerned with the types of phenomena that *protoplasm* supposedly refers to? By no means! For (see Table 1) during the same quarter-century, the frequency of entries under "proteins" had *increased* by 85 percent; under "vitamins," by 216 percent; and under "enzymes," by 945 percent. Plainly, biologists are more than ever concerned with investigating the basic phenomena of life, but increasingly less often do they find the term *protoplasm* useful in describing their researches.

Protoplasm is disappearing from research; what about teaching? Here, I suspect, progress is not so rapid. There is always a considerable lag in teaching. Many years ago it was remarked that the military academy of St. Cyr in France trained its students splendidly to fight the battles of the *last* war. So it is in science teaching; we too often train our students to fight battles already won, or equip them with weapons that no longer fire. *Protoplasm* is certainly such a weapon. But it will probably be with us for a long time, for various reasons. For one thing, it is already in the textbooks, and each new textbook writer is under subtle, but real and powerful, pressure to include in his book all the conventional words. "But where's protoplasm?" he can hear people say. "What's the matter—don't you know your subject?" So, in the word goes again.

Another source of the cultural lag is to be found, I believe, in the training of the teachers of biology. In a good university, a student majoring in microbiology, general physiology, genetics, biophysics, or biochemistry can hardly fail to develop a working concept of the organism as an open system, with which the concept of protoplasm is incompatible. But will he later pass the open-system concept on to students of elementary biology? It is not very likely, for the student trained in the fields named will probably end up in research or in teaching in departments bearing the titles "Microbiology,"

Table 1. The replacement of "protoplasm" by other subject hearings in *Biological Abstracts*.

Subject heading	No. of entries per 10,000	
	Vol. I, 1926–27	Vol. 25, 1951
Protoplasm	7.6	0.95
Proteins	21.4	39.5
Vitamins	29.2	92.7
Enzymes	15.2	158.8

"Physiology," and so forth. I believe that careful studies would show that the student who becomes a teacher of elementary biology most often is himself a major in botany or zoology and, as such, has only desultory contacts with the lines of modern research that should influence his thinking in such matters. If this hypothesis of mine is correct—that there is now an increasingly sharp separation of the students destined to become teachers of elementary biology from those who end up working on the frontiers of scientific research—if this is correct, then academic biology is faced with a serious crisis (*18*).

There is still one more reason for the probable persistence of *protoplasm* in the future—this one a rather noble reason, in its intentions—namely, the desire to make things "clear" to the students. All students, quite rightly, put pressure on teachers to simplify and make difficult ideas clear. The conscientious teacher, with one eye cocked on mechanical examinations (so-called "objective examinations"), tries to help the student, and he sometimes "helps" too much. Rather than making difficult ideas clear, he sometimes chooses to present erroneous but "clear" ideas in preference to more correct ideas that are intrinsically less clear. This is but the working out of a "Gresham's law" of ideas, a major plague of education. The idea of an "open system" is not an easy one to grasp or to adapt to the exigencies of mass examination. The erroneous "closed-system" model of life, with its mythical protoplasm, unfortunately meshes all too well with the metalinguistic structure of western European languages. But, once we see where the conflict of interest lies, we cannot, with good conscience, prefer "clarity" to truth. As Whorf has said (*19*):

> I can sympathize with those who say, "Put it into plain, simple English," especially when they protest against the empty formalism of loading discourse with pseudo-learned words. But to restrict thinking to the patterns merely of English, and especially to those patterns which represent the acme of plainness in English, is to lose a power of thought which, once lost, can never be regained. It is the "plainest" English which contains the greatest number of unconscious assumptions about nature. This is the

trouble with schemes like Basic English, in which an eviscerated British English, with its concealed premises working harder than ever, is to be fobbed off on an unsuspecting world as the substance of pure Reason itself. We handle even our plain English with much greater effect if we direct it from the vantage point of a multilingual awareness. For this reason I believe that those who envision a future world speaking only one tongue, whether English, German, Russian, or any other, hold a misguided ideal and would do the evolution of the human mind the greatest disservice. Western culture has made, through language, a provisional analysis of reality and, without correctives, holds resolutely to that analysis as final. The only correctives lie in all those other tongues which by aeons of independent evolution have arrived at different, but equally logical, provisional analyses.

In the necessity of discarding "protoplasm," biology is now confronted with a painful decision of the sort that faced its older sister science, physics, more than half a century ago—the necessity of denying "common sense." When it became clear that the "self-evident" Euclidean framework did not work for the universe in the large, there were many who would have denied the consequences of logic and experiment rather than abandon the metalinguistic presuppositions they called "common sense." A similar crisis arose again when the "indeterminacy of nuclear electrons" was postulated. Reason finally triumphed over common sense, although it took a generation or two to do so. We would be unjustifiably sanguine to expect a speedier demise of "protoplasm."

References and Notes

1. I do not give the references for these quotations, believing that the works from which they are drawn should not be subjected to explicit adverse criticism. The statements are fairly representative of this class of books.
2. H. Vaihinger, *The Philosophy of 'As If,'* C. K. Ogden, Trans. (Routledge and Kegan Paul, London, ed. 2, 1935).
3. J. Needham, Ed., *Hopkins and Biochemistry* (W. Heffer, Cambridge, 1949). This collection includes Hopkins' very human *Autobiography*, sketches of him by Marjorie Stephenson and the Needhams, and reprints of "Hoppy's" most influential papers.
4. E. L. Oginsky and W. W. Umbreit, *An Introduction to Bacterial Physiology* (Freeman, San Francisco, 1954). This up-to-date treatise is notable for the clarity with which it treats the complex subject of metabolism.
5. We should not be too severe with those in the grip of an irresistible panchrestic urge. Although a panchreston may be meaningless in one sense—in its reference to the external world—it may have very considerable meaning internal to the person who uses it. Laplace's dictum may be regarded as devastating to the panchreston of external reference, but it hardly touches it in its other aspect, as is evident from the fact that the great contemporary English philosopher John Wisdom (what a wonderful name for a philosopher!) has been able to write a really illuminating essay on "Gods" almost a century and a half after Laplace's apocryphal reply to the little Corsican. Those who love *protoplasm* may hope, perhaps with reason, for the appearance of a similarly illuminating essay on "Protoplasms" a century or so from now. Those who have not read Wisdom's modern classic may find it, *inter alia*, in J. Wisdom, *Philosophy and Psycho-analysis* (Philosophical Library, New York, 1953).
6. G. Hardin, *Biology: Its Human Implications* (Freeman, San Francisco, ed. 2, 1952). See especially Chap. 34, "What is life?"
7. J. Bronowski, *The Common Sense of Science* (Heinemann, London, 1951), pp. 132–133.
8. The brief account of Whorf's life is taken from an anonymous obituary printed on pages 29–30 of the September 1941 issue of *The Hartford Agent*, the house organ of the Hartford Fire Insurance Co., for which Whorf worked.
9. B. L. Whorf, "Science and linguistics," *Technol. Rev.* **42**, 229–231, 247, 248 (1940).
10. ———, "Languages and logic," *Technol. Rev.* 43, 250–252, 266, 268, 272 (1941).
11. G. L. Trager, *The Field of Linguistics*. Studies in Linguistics: Occasional Papers I (Norman, Okla., 1950), citation from *ETC* **9**, 163 (1952).
12. A. N. Whitehead, *Science and the Modern World* (Macmillan, New York, 1925), p. 49.
13. R. Schoenheimer, *The Dynamic State of Body Constituents* (Harvard Univ. Press, Cambridge, Mass., 1942).
14. N. W. Pirie, "The meaninglessness of the terms life and living," in *Perspectives in Biochemistry*, J. Needham and D. E. Green, Eds. (Univ. Press, Cambridge, 1937).
15. L. von Bertalanffy, "The theory of open systems in physics and biology," *Science* **111**, 23 (1950).
16. I use *validity* in Rapoport's sense. A. Rapoport, *Operational Philosophy* (Harper, New York, 1954), Chaps. 3 and 4. I would assert that, as regards fundamental aspects of living organisms, only those sentences involving the phrase *open system* may be true. One can construct valid sentences (that is, consistent sentences) using either *open system* or *thing* (or some of its surrogates). But sentences involving *thing* become invalid (inconsistent, at least in their implications) upon the substitution of *open system*, and vice versa.
17. F. Mainx, *Foundations of Biology*, vol. I, No. 9 of *International Encyclopedia of Unified Science* (Univ. of Chicago Press, Chicago, 1955), p. 25.
18. If it seems that I am unjustifiably critical of those who teach elementary biology, let me point out that I myself belong to the class criticized. As an undergraduate, I majored in zoology, and I have taught elementary biology, off and on, for 15 years. If I differ at all from my colleagues it is in having been unusually fortunate in my contacts with those who work at the physicochemical frontiers of biological science, as I myself am untrained to do.
19. B. L. Whorf, *Collected Papers on Metalinguistics* G. L. Trager, Ed. (Department of State, Foreign Service Institute, Washington, D.C., 1952). References 9 and 10 are included in this publication.

Human Resources and National Security

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Some Problems of Scientific Manpower

THERE are five preconceptions about scientific manpower that have wide currency. One stipulates that the United States is suffering from a severe shortage of scientists and engineers and that our basic security is threatened by the prospect that the U.S.S.R. may outproduce us in the number of trained personnel. A second holds that the United States is wasting a large percentage of its intellectual potential because little more than half of all the young people in the country with good native intelligence complete college. A third preconception holds that if the nation is to increase the number of able young persons who are interested in pursuing careers in science, it will be necessary to strengthen the high schools of the country, particularly with respect to their offerings in mathematics and basic science. A fourth formulation holds that the Armed Services, which have become the largest employer of manpower in the country, are conspicuously wasteful when it comes to the utilization of highly trained scientific and engineering personnel. Finally, a fifth proposition holds that any marked increase in the numbers who choose to pursue a scientific profession will depend in large measure on an alteration in the basic attitudes of the American public so that the status of scientists and engineers can be substantially improved.

These five preconceptions seem to be so obviously true as to leave little opportunity for critical appraisal. Yet closer inspection may disclose that the obvious is, after all, not quite so obvious.

It may not be out of place for an economist to begin the inspection of the theorem that we are suffering from a shortage of scientists and engineers by stressing that in a world of limited resources we are always short. There is a shortage of good baseball players, of top-flight business executives; beautiful women are in short supply; competent philosophers are likewise scarce. How could it be otherwise, then, than that there would be a shortage of good scientists and engineers? A related consideration is the arbitrariness, and in fact the fickleness, of the demand for scientists and engineers, at least for a large part of the total demand. During the last few years, the Congress of the

United States has seen fit to make available approximately $2 billion annually for research and development, an amount that is more than half of the total annual expenditures for these purposes. It is no secret that recently there has been a threat of a 20-percent reduction in the research and development budget of the Armed Forces. If such a reduction should in fact take place, much if not all the present shortage of scientists and engineers, viewed at least in gross quantitative terms, might disappear overnight. Clearly, if the Congress decided to increase appropriations for research and development from $2 billion to $3 billion, the shortages would reach astronomical heights.

What about the relative position of the United States vis-à-vis the Soviet Union in the training of scientists and engineers? Considering what we do not know about our own scientific and engineering manpower resources, comparative analyses of the United States and the Soviet Union would seem to rest on shaky grounds. To advise caution about such comparisons does not commit one to lack of concern about the magnitude and quality of the effort the Soviet Union is making to strengthen its scientific manpower resources. From the earliest days of the Communist Revolution, the leaders of the Soviet Union have recognized the importance of overcoming the scientific lead of the West and have striven to do what they could to enlarge their scientific manpower resources.

Some months ago, a leading newspaper gave emphasis to the threat of U.S.S.R. scientific superiority by detailing not only what is going on within the Soviet Union itself, but including also quantitative data on the training of scientists and engineers in the satellite countries. There is little reason to question that Hungary, Rumania, Poland, and Bulgaria are turning out varying numbers of scientists and engineers, although it is indeed questionable whether anyone in the United States has any clear perception of the true magnitude and, more important, of the quality of this effort. But this fact calls attention to the somewhat startling failure of most of the comparative studies to include on the side of the West not only the American figures but also those of Canada, Great Britain, France, Western Germany, and the other allied nations. Nor is proper weight given to the observation of a well-informed Government scientist that the Soviets are anxious to translate the textbooks and scientific treatises of the West, but that there has been little need as yet for Western translations of the scientific material available from behind the Iron Curtain.

Since the population behind the Iron Curtain is considerably larger than that of the United States, there is nothing to stop the leaders of the Soviet Union, if they are determined to do so, from raising the output of scientists and engineers above the American level. But it would be well to remember that the same power that could bring about this result also brought about an agricultural policy decision some years ago that resulted in the slaughter of perhaps as much as 50 percent of the total livestock of the country. It is possible for any country, through compulsory powers or through incentives, to increase substantially the number of trained people in any particular sector of life. What no country has yet been able to accomplish is to insure that highly competent people rise to the top in every sector of life. There were many good scientists in Germany in 1933, but that did not prevent Hitler from coming into power. To reduce all considerations of national security and welfare to concern over the number of scientists and engineers would be the rankest type of materialism. It would also be to withdraw behind an intellectual Maginot Line.

What about the second preconception, which holds that we are wasting about half of the best brainpower of the country because only about half of the boys and girls in the upper range of intelligence-test results complete college? Several points are worth noting, each one of which must be assessed before a valid conclusion can be reached about this particular thesis. About half of the most intelligent young people who fail to complete college have been so little attracted to their studies during their high-school careers that they have failed to complete secondary education in the upper fifth of their classes. It may be stated that students who are not in the upper fifth of their high-school graduating classes are poor bets for becoming outstanding scientists or engineers. Forty percent of all students who score high on intelligence tests fail to take college preparatory courses. Although they have the intellectual potential to pursue a college education successfully, they have not qualified themselves to do college work. Since the present concern with this wastage of brainpower derives largely from a desire to increase the number of students who will pursue scientific or engineering careers, it is well to note that one-half of all those who score high on intelligence tests are girls and that only one girl out of ten secures in high school the foundation in mathematics necessary for college study in engineering and science. Hence, even if many more able girls were encouraged to go on to college, it is doubtful that any significant increase would take place in the total numbers preparing for science and engineering.

It would be a serious error to overlook the fact that it would be a disservice to many individuals, and also to the country, if every person of high

intelligence were persuaded to go to college. The leadership of such institutions as trade unions continues to be chosen from the noncollege group. It is clearly in the national interest to have able people compete for these posts. Although our culture places little emphasis on the arts, it would surely be a questionable national policy to exert direct or indirect pressure on the promising musician or artist to attend college when he might well develop his talents more effectively through other means.

There are unquestionably a considerable number of able young men and women who do not now enter college but who, with encouragement, financial assistance, and better guidance, might do so, and thereby more effectively develop their potential and be in a better position to make a significant contribution to the nation. The point of the foregoing analysis has been to challenge the assumption that we are wasting 50 percent of our brainpower.

One of the most salutary effects of the recent preoccupation with the supply of scientists and engineers has been to focus a new spotlight on the state of secondary education. Appalling conditions have been revealed. No mathematics is taught in one-quarter of the high schools in one southern state. In many parts of the country, it is usual for the football coach to teach science as a secondary duty, since science is a man's subject. The recent efforts of the American Association for the Advancement of Science and other groups to seek remedial action are to be commended, but it seems unlikely that any significant improvement can take place in the short run.

The problem is not limited to science and mathematics in high schools, but involves the whole status of high-school teaching. Consider for a moment the contrast between the circumstances of our high-school teachers and the status in the community, the salary, and the opportunity for meaningful work that were accorded to the *Gymnasium* professor in pre-Hitler Germany. It may not be out of place to mention in this connection that it would hardly be a national gain for high schools to strengthen their instruction in science and mathematics and neglect to improve the teaching of English and history. A society of technically trained illiterates is no desideratum. From the viewpoint of public policy, this renewed interest in the status of secondary education must not be permitted to become an unbalanced preoccupation with one area of secondary education. Rather, it must be used as leverage to improve the quality of secondary schools across the board. Considering the tremendous stress that schools will soon be under because of rising enrollments, any substantial improvement is likely to come, at best, very slowly.

The fourth preconception singles out the Armed Services as a major waster of trained manpower. The typical formulation runs as follows: Unless the Armed Forces have need for a chemical engineer or physicist, they should defer him so that he can pursue his specialty in civilian life rather than waste his time, and more particularly his skill, in the performance of military duties. If this contention were limited to men with a Ph.D. degree who were needed for research, teaching, or defense work, it could be soundly defended. But it is often applied indiscriminately to the tens of thousands who receive bachelor's degrees in one of the sciences and obtain positions in industry that have no relationship to defense effort. One aspect of the problem that is seldom considered is the likelihood that in many instances the individual will be able to develop his full potentialities more through a tour of duty with one of the Services than through a 2-year assignment at the drafting board in a large corporation's engineering department.

But all of these considerations of efficiency aside, it is well to remember that we are citizens first and scientists and engineers second. In periods of full mobilization, it is obviously necessary to use every man at his highest possible skill, but at a time like the present when we are devoting but a small part of our total national effort to defense, considerations of equity cannot be lightly ignored. The economy depends on skill, but democracy depends on more than skill.

The fifth and last preconception stresses the importance of a change in basic values in favor of science and the scientist, without which no substantial increase in the number of young people who pursue a scientific career can take place. In simple terms, the proponents of the position argue in favor of an increase in the income and prestige of the scientist. Alterations in the basic values of a community are always hard to bring about, particularly in the short run. But the question must be asked whether any real effort should be made to bring about this change in favor of science alone. What about the other important human activities that have such difficulty finding a place in the sun—the humanistic, the artistic, and the religious activities? Is it not equally important from a national point of view to deepen the American public's understanding and appreciation of the artist, the writer, the man of God? Why single out the scientist or the engineer?

There is probably much that could be altered for the good if some of the national energy that is now devoted to the making of goods and money could be deflected to other ends. But to establish

as a primary end quantitative increases in the number of scientists and engineers hardly seems a worthy national objective of and by itself, important as it may be within the context of the larger goal of stressing the intellectual rather than the practical in national life.

If we are dissatisfied with quantitative approaches to the problems of scientific manpower, what other approaches should be pursued? It would be well to start with a consideration of the nature of the scientist. Two years ago the National Manpower Council published its report on *A Policy for Scientific and Professional Manpower*. Included therein is a chapter on the physicist that benefited greatly from the ideas of Lee DuBridge, a member of the council. DuBridge emphasized the subtle combination of qualities required in a good physicist: a high order of general intelligence, a special interest in mathematics, a tolerance for indeterminate solutions, and finally, an emotional involvement with the subject matter of physics proper, which he best described as a state similar to "falling in love." Clearly, the development of a larger number of competent scientists is very much more than a technical matter such as is involved in raising the production of steel or of automobiles. We are not dealing with what the economists call freely reproducible goods. The beginning of wisdom is to recognize the inherent limits set by the order of qualities required.

In a recent issue of the *Harvard Alumni Bulletin,* Lawrence Kubie, the distinguished psychoanalyst, discussed how the weak financial position of the universities is discouraging young people from pursuing careers in research and teaching. He stressed the fact that it is impossible for the young scholar and scientist to maintain a standard of living that does not place undue burdens on his wife and children. Although Kubie does not make the point, it has seemed that we have been shadowboxing for many years now with respect to the financing of higher education. At present, selected universities receive about $400 million annually from the Federal Government for research and development work. They feel free to take this money because it is for contract work, while they would have qualms in asking for a general Government subsidy. Yet it is widely recognized that many assignments on Government contracts deflect people from important to less important problems, from areas of primary concern to areas of peripheral interest. Moreover, contract funds are not a sound basis for providing the long-term security and perquisites that are the key attractions to the university scientist and scholar, who above all wants a balance between teaching and research with the freedom to determine the directions of his own work.

Another point worth raising is the probable distortion that has come about in scientific effort as a result of the international situation, which it would be insane to ignore and yet foolhardy to respond to without balance and circumspection. Most Government research funds are spent on applied research and the practical development of new weapons. Relatively little is spent on the basic research that is the necessary foundation for radical future alterations in civilian as well as military technology. One acute observer has remarked that we have a shortage of first-rate men to work on second-rate problems.

A fourth factor, little recognized, grows out of the trend toward a younger age of marriage. At present one out of every four girls is married at 18, and more than half are married before 21. What is more, couples tend to have their children during the early years of marriage. As a result, a young man who, in the 10 years after acquiring his doctor's degree, should be concentrating on deepening his knowledge and skills is likely to be harassed by mounting family expenses. To an alarming degree, the abler young people are leaving the university for greener pastures in industry, with the result that the teachers of the next generation and those with primary responsibility for basic research may soon represent second- and third-best talent, rather than best talent.

A fifth factor worth stressing is the difficulty in a large country such as the United States where there is a penchant for organizational activity of not interfering with the effective performance of outstanding scientists. Wesley Clair Mitchell, a remarkably disciplined scholar, was appalled to note at the end of every year what a high proportion of total working time had been deflected from his basic research. And the testimony of Einstein was to the effect that the atmosphere in the United States is not conducive to reflective thought.

These are but a few of the neglected factors that clearly help to determine the quality of scientific manpower and the effectiveness with which it performs. Imbedded in the foregoing analysis are at least three major policy determinations that the nation must make in the immediate future.

With bulging enrollments at both the high-school and college levels, we must begin to face the question of what we want high schools and colleges to do. Should the high school remain a common school where the instruction is geared to the average student? Should all who want to go to college and who possess the minimum intellectual qualifications be admitted? Or should we try as a people

to make a more self-conscious determination of the additional resources that we want to make available for educational purposes and to consider more critically than we have in the past the most effective way of using such resources to insure, not an increase in the number of years that people spend at school, but rather an increase in the effectiveness of each year that a person is in school in terms of knowledge gained and skills acquired.

A second very difficult question that awaits evaluation, if not solution, is the changes that are called for with respect to the fuller development and more effective utilization of the potential of American women, who represent the majority of high-school graduates and a high percentage of college graduates. If there is serious concern about increasing the number of highly trained persons in our society, we should recognize that women represent the greatest potential supply.

Finally, there is a need to appreciate fully the crucial role of the university in producing both new scientists and new scientific knowledge. In this area, there are at least three major problems: more adequate financing of higher education, keeping enough distinguished scientists in the universities, and determining a proper balance between basic and applied research. These problems cannot be solved apart from each other, nor can they be solved by the universities alone, for the actions of industry and government have a profound effect on each. Until this strategic area is seen as a whole and until a sound and imaginative program for the strengthening of the universities is developed, improvisation will continue. When forced by poverty to improvise, no university community can make its maximum contribution to society.

The solutions to these and allied problems will not be easy to come by. In a democracy, a role will be played by the legislator and the general, as well as by the industrialist and the university administrator. But the real challenge is directed to the leaders of science. It behooves them to be worthy of their position, to eschew the temporary and expedient, and to show the hallmark of true leadership by contributing sound analyses and presenting solutions worthy of the great tradition of which they are the contemporary spokesmen.

Manpower Requirements of the Military Establishment

It is necessary in analyzing problems of military manpower to determine what manpower is required to win a war that may have to be fought or what is required to establish positions of strength in prewar or cold-war conditions, rather than to dwell on the purely organizational needs of the military establishment. Our military establishment was completely lacking in formulated ideas concerning its needs in manpower, raw or trained, at the beginnings of World War I and World War II. It was not prepared in 1917 for the war of position that was foreshadowed in 1914, nor was it prepared for the war of movement—blitzkrieg—in 1939–1940. The Eberstadt Report indicated that inadequate attention was given to the manpower aspects of mobilization and that realistic plans for effective over-all allocation and utilization of manpower did not exist.

The general neglect of manpower was also evident in the lack of plans for industrial mobilization. The Assistant Chief of Staff, G-1, was responsible for military manpower, and the Assistant Secretary of War was responsible for industrial mobilization. The responsibility to provide the manpower to make the weapons, munitions, and equipment needed by the Armed Forces was unassigned—and at a time when the Armed Forces were taking the younger workmen into service. The industrial mobilization plans even up to 1939 were devoid of adequate manpower provisions, although Enoch Crowder, in his report as provost marshal general in World War I, clearly indicated the need.

Military manpower requirements are now determined annually after consideration by numerous agencies of the Federal bureaucracy from the National Security Council down. The problem is settled, of course, by the Congressional appropriations. One wonders whether this entire consideration is not in terms of existent (or competitive) organizations instead of in terms of a functional use of manpower if and when needed. The military itself might admit that this method is inadequate for determining manpower requirements, and the Congress might believe reasonably enough that the military consideration of the problem is static rather than dynamic and functional. How deeply the general manpower problem is involved in the aggregate population, however, has been overlooked in the narrow conceptions of compartmentalized-thinking on military manpower. The realistic solution by means of the budget does not appear to be a solution of the actual military manpower problem, although it might be a solution of the immediate political problem.

Clarity requires that the concept of "military" be cast in a rather broad outline. It is not merely that of the combat soldier. The Hoover Commission classifies personnel for "military activities" as follows: (i) personnel for the military activities, (ii) personnel for the combat-related support ac-

tivities, and (iii) personnel for the supplier-related activities. The military activities include combat, combat training, and other activities of a miltary operational character. The combat-related support activities are concerned with logistic support such as procurement and supply, transportation and communication, materiel maintenance, and care of combat personnel. Personnel in these types of activities can be interchanged with those of the fighting forces and can accompany them forward to combat zones. The supplier-related personnel include those who possess most of the skills employed in the civilian economy and who are oriented toward business, industry, science, and the professions. They do not need to accompany the fighting forces into forward combat areas and are reasonably stable in location.

The concept of "military" is complicated by the existence of women in the military services. The functions they perform are not combat services. The question has been raised whether civilian women could not replace many military personnel in the Department of Defense. The Hoover Commission has alluded to this problem as a unique personnel problem in the Department of Defense with reference to military and civilian personnel who work together without clear delineation of the role appropriate to each.

The basic distinction between civilian and military personnel is not sharp and is often difficult to recognize. The popular conception identifies "military" with "combat." In World War II, it was impossible to obtain a definition of combat troops. All in uniform were at first thought to be, potentially at least, combat troops, but the presence of women in the military services showed that this was not true. The fact that civilian and military personnel do the same work has blunted the distinction between them. The fact that civil defense will undoubtedly require the invoking of martial law (under the military authorities) still further invalidates it. And it must be remembered that the American Armed Forces in wartime are primarily composed of civilians in uniform.

Manpower obviously includes womanpower—our greatest reserve of human power that can be used to meet the needs of a war economy. The usual definition of manpower is the number of people over 14 years of age who are capable of doing useful work. In this form, population statistics are sometimes compared nation against nation, bloc against bloc. But the level of gross raw statistics tends to mislead. To think of manpower in national totals—whether for the military, industry, or the supporting civil economy—is to indulge in a statistical mirage. Little is actually known about the comparative situations of two nations if one has merely the knowledge that they each have a population of 1 million. If armed hordes were fighting armed hordes, such figures might have some significance. But in technological war, the quality of the manpower increases in importance. Numerical figures must be interpreted in terms of the character of the nation itself. For example, a nation in an advanced stage of industrial and technological development has a tremendous advantage in manpower potential. Other important factors, in addition to the stage of industrialization, are the maturity of the labor movement and its leadership; the national character; the public attitude toward war and conscientious objectors; minority groups and their psychology; the attitude toward expending human life; educational, apprentice, and technical training of the people; the stage of scientific research and development; the strength and amount of infiltration by subversive movements; and the age, sex distribution, and health of the population.

The basic manpower requirement is that manpower necessary to insure victory in war. There must be a strategic plan based on full research, intelligence, and imagination to meet all the potentialities of the assumed enemy and its allies. This plan, in part, will be conditioned by the commitments of foreign policy. If this policy has been one of appeasement and half-hearted preparedness, politics will have been played with manpower and diplomats will have permitted the development of a situation that requires either supine surrender or a high cost in manpower for belated courage and wisdom. To paraphrase Clausewitz, war is only a continuation of politics by a different means; it has its own grammar but not its own logic (*1*).

Manpower (that of ourselves and our allies) must be determined in the present situation by the strategic plan for meeting the U.S.S.R. and its allies at the decisive moment. Tactical plans will make manpower requirements more specific, but these plans will develop up to the time of battle. Requirements must be interpreted not in terms of organizations or in a vacuum, but in the dynamic terms of a function—the function being the implementation of a strategic plan (*2*). Manpower is the central factor in such implementation and tactics makes it more definite. But strategy—grand strategy—is a function of both politics and the military.

An important part of the manpower problem is the principle of the military-industrial balance—or, in its widest sense, the military-civilian balance. The principle is illustrated simply. Every time a man is placed in military service there must be

provision for feeding, clothing, housing, transporting, and equipping him. Every time a man is kept in industry or in the civil economy there is a man who does not go into military service. By this balance is obtained the optimum number of men that can be placed in military service together with the provision for all means to make him effective in terms of the capacity of the nation. This is the military-industrial balance. But the men in industry too must be fed, housed, and clothed, and these functions are performed by the rest of the civilian economy. The farmers, for example, feed the military, the industrial personnel, and all others, including themselves. In this sense, there is a balance between the military organization and all its supporting activities. This broader balance is the military-civilian balance.

A major problem in military manpower is the age of military effectiveness. In previous wars, the obligation of military service was placed on all male persons between the ages of 18 and 45 who were citizens of the United States or who declared their intention of becoming citizens. In World War I, although the obligation of military service included the 18-to-45 age group, the first registration was for ages 20 to 30. At later registrations, the age limit went down to 18 and up to 45. In World War II, the changes of attitude on the part of the Armed Services concerning the acceptable age for military service may be indicated as outlined in Table 1.

Table 1. Age and military manpower in World War II.

Age	Date	Authority
Persons liable for registration		
21–35	16 Sept. 1940	Public Law 783, 76th Congress
18–64	20 Dec. 1941	Public Law 360, 77th Congress
Actual registrations		
21–35	16 Oct. 1940	President's proclamation
21	1 July 1941	President's proclamation
20–45	16 Feb. 1942	President's proclamation
45–65	27 Apr. 1942	President's proclamation
18–20	30 June 1942	President's proclamation
18	1 Dec. 1942	President's proclamation
18	Continuing on birthday beginning 1 Jan. 1943	President's proclamation
Persons liable for service		
21–35	16 Sept. 1940	Public Law 783, 76th Congress
21–27	16 Aug. 1941	Public Law 206, 77th Congress
20–44	20 Dec. 1941	Public Law 360, 77th Congress
18–44	13 Nov. 1942	Public Law 772, 77th Congress
20–35	14 May 1946	Public Law 379, 79th Congress
Persons acceptable for induction		
18–37	5 Dec. 1942	Administrative Action
18–25	15 Aug. 1945	Administrative Action
20–25	16 May 1946	Administrative Action

The restriction of inductees to a narrow age group centering around the twenties has greatly complicated the manpower problem in wartime. For example, this conclusion regarding the desirable age for the Armed Services, which developed as World War II progressed and was not set as initial policy, permitted large numbers of the military age grouping to take jobs in industry. By successive 6-month deferments, these persons became "nominal" or real experts and presumably were no longer available for military service. Deferment of college students in wartime will complicate this matter, and when washers of test tubes in laboratories or even majors in science in college courses are called "scientists," the problem is merely evaded.

Another complication of military manpower is that of physical requirements. The general attitude is that persons are either fit or unfit for military service. At the beginning of World War II, there were classifications of those fit for general military service, those fit for general military service with remediable defects, and those fit for limited military service. Few of the last class were ever called, and hospitalization complicated the second. When there were many complaints about the numbers in Class 4F—those physically unfit for service—an Armed Services Committee saw no opportunity either to use them or to change the standards.

The efficiency or wastefulness of the Armed Forces themselves affect military manpower requirements. The Hoover Commission made references to "inefficiencies" in the Department of Defense, and, obviously, organizations that permit such conditions will be wasteful of manpower (*3*). In 1943 the President publicly criticized the Selective Service System for not furnishing men to the Army. It was discovered later, however, that the Army had already exceeded its authorized strength by several hundred thousand men. The explanation given was that casualties did not occur in the number expected.

There would be no point in knowing the population of the United States or the character and qualifications of its people for the purpose of war or national defense if they could not be located, allocated, utilized, and trained. Volunteering is an ineffective and wasteful system. The approved method of raising armies or meeting military manpower requirements is by induction by a Selective Service System, with a lingering reliance on enlistments that are largely the result of the coercive power of the draft. The Selective Service System was a tremendously popular success both in World War I and in World War II. It achieved its purpose. But the fact that we "won the war" should

not be taken as sufficient sanction that what was done was "best." This attitude, unfortunately, has been too general. One perfect example is Troyer Anderson's report on the procurement of munitions by the War Department under the direction of the Under Secretary of War that is entitled "Munitions for the Army." An evaluation of our success in war should recall the reference in the Eberstadt Report that achievement was gained at the cost of much waste of material, manpower, and money.

The Selective Service System in World War I raised by enlistment and induction 4 million persons for the Armed Forces out of a population of 103 million. In World War II, when the balancing of the military and industrial manpower needs became critical, there gradually arose a number of problems that required additional administrative machinery. Among the administrative bodies set up to solve these problems were the War Manpower Commission and the Economic Stabilization Board. There was a very clear indication that the situation required the development of more definite machinery for the control and direction of civilian manpower. Some refinements that were developed in World War I such as special calls for specific needs of the Armed Forces for workmen with particular skills were not used in World War II. A specific policy of "work or fight" was not employed in World War II, although approaches to the policy were used. Persons not physically qualified for military service who were in essential jobs were required to remain there even though, by the normal rules of Selective Service, they were theoretically free. It became necessary, however, to adopt special regulations for "job jumpers" who were able to be inducted after the Army reduced its physical standards in such cases. In World War II, there were many certification plans to aid local boards, the most publicized of which was the West Coast plan for the aircraft industry.

While the primary function of the Selective Service System was to secure men for the military service, the system was also responsible for attempting to maintain the military-industrial balance. Selective Service was obligated to see that the withdrawal of men for military service disturbed the civilian war effort to the least possible extent. As increased demands for men came from the Armed Forces, however, the balance could not be maintained. The absence of policy on the part of the War Department, the lack of an adequate survey of the industrial skills of the country, and the increased demand for manpower in the war industries made a full performance of the task impossible.

Those who were to carry on industrial and agricultural production and the work of the civilian community were men outside the military ages, women, prisoners of war, or imported labor. With respect to military manpower, those who were not physically qualified for military service or who were deferred as necessary by the Selective Service System on an individual basis were also available. Dependency deferments affected large numbers of essential workers. Later, these deferments were withdrawn; this greatly increased the number who were considered directly for industrial and agricultural deferment. These decisions were made by 6443 boards and were reviewed by 1000 appeal boards.

The great weakness of the Selective Service System was lack of a positive policy for industrial and civilian manpower. Although numerous agencies were created to handle this problem, there was little actual coordination between them and the Selective Service System. The creation by Executive Order of the Office of Economic Stabilization (6 October 1942) and the Office of War Mobilization (May 1943) did not clarify or unify manpower policies. Proper organization and administration are needed to integrate into a positive policy all these elements with the new elements that will be made necessary by atomic war. Changes within Selective Service in wartime show a definite trend toward national service. But perhaps a radical reconsideration of the Selective Service System is more than we are prepared to accept (*4*).

It may be that a discussion of military manpower requirements is entirely beside the point. The communists believe that everything can be achieved without a hot war. Armies are not needed when espionage agents, saboteurs, and fronts are successful. An error is often made in distinguishing between the U.S.S.R. as a nation and the Communist International as a world conspiracy and revolutionary movement. Communists use the national status of the U.S.S.R. to deal with other states and are accorded a position in the family of nations that the international conspiracy as such could not obtain. Cold war is communism's constant instrument in its clear, unmistakable, and unwavering purpose: the mastery of the world, the demise of capitalism, and the end of every religion not subsequent to its final purpose. In contrast to the drifting hopefulness and forgetful erring of the noncommunists, the communists never lose sight of their ultimate objective. No military campaign was ever worked out more painstakingly, with more attention to detail, with more careful timing, and with more patience than the seemingly irresistible day-by-day, hour-by-hour action of com-

munists everywhere. They have devised the most subtle and cunning methods of making traitors in every country and of using idealists and the so-called intelligentsia, and their success has indicated no need for war. The threat of war has been a means of creating a state of unrest and insecurity for their enemy and a means of causing a waste of money, manpower, and materials in a mad armaments race for a mythical superiority.

In any case, the net result of a discussion of the military manpower problem should be that it is not a simple problem of numbers. It is not a problem of ratios of the mechanically minded or the compromises of a bureaucracy of budget makers. It goes to the basic characteristics of the people and the economy and to their international policies. It involves the highest type of imagination in procurement, training, and utilization. It builds most certainly on the efficiency of government and of military organization. And above all, the quality of manpower—in sufficient numbers and properly utilized in cold war or hot for the common defense—is the key to our national existence (*4a*).

Human Resources in American Industry

The measure of any nation's strength is in its productivity. Efforts to assign statistical values to industrial strength have not been particularly successful, whether the values are expressed in such monetary terms as gross national product, capital investment, or per capita income, or in such manpower figures as the number of people gainfully employed. Neither money nor manpower gets quite to the crux of the quality to be measured, which is output. Without debatable adjustments, the monetary yardstick inevitably reflects transitory, and sometimes violent, changes in purchasing power. As for the human factor, 65,000,000 gainfully employed workers in the U.S.S.R. or in China have a far lower productive capacity under present conditions than an equal number in the United States.

Industrial strength—and, with it, national security—is compounded of human skill and manufactured energy applied to the processing of available raw materials. No one of these ingredients possesses much intrinsic worth without the other two, and no two of them have sufficed to make or to keep any country great since the industrial revolution relegated manpower, in the literal meaning of the word, to a place of secondary or tertiary significance, and elevated skill, or brainpower, to a place of primary importance.

Unless we wish to embrace the dubious and discredited tenets of racism, we Americans must regard our own people as ordinary human beings with no mental or physical characteristics that are not shared by the human race as a whole. Yet, industrially, we are admittedly the most productive of nations. A look at history must convince Americans that we are descended from common stock and drawn from many sources. Colonial settlement by the English, Dutch, and Swedes was followed by German and Irish immigration. The Congress cut the influx to a trickle when migrants from Italy and eastern Europe became numerically strong. For the most part, immigration was regarded as a means of importing unskilled labor—the "strong backs and weak minds" that would relieve the earlier arrivals and their descendants of menial work.

Somehow, the minds of immigrants never remained weak, for the free educational system of the New Country and the unlimited opportunity offered by the frontier quickly destroyed the vestiges of any caste systems that may have clung to some of the immigrants. The melting-pot theory, according to which the racial mixture imparted unusual vigor and acuity to Americans, lacks substantial supporting evidence. The only tenable conclusion is that the American people have educated themselves out of the category of unskilled, or common, labor and are now in the process of reducing the number of semiskilled workers in labor's ranks.

In broad terms, the 65,000,000 gainfully employed workers in this country engage in the following activities: agriculture, 13 percent; industry, 35 percent; service (including commerce), 45 percent; Government, 4 percent; unclassified, 3 percent.

Classified somewhat arbitrarily on the basis of the caliber of the work performed, America's labor force consists of the following groups: unskilled workers, 12 percent; semiskilled workers, 20 percent; skilled workers, 45 percent; specialized workers, 12 percent; managerial workers, 11 percent.

These generalizations are based on ratios that were determined from the 1950 census, but they involve a few arbitrary decisions concerning what constitutes service as distinct from industrial production, and where to draw boundaries between semiskilled, skilled, and specialized employment. The last of these categories includes teachers and technicians, as well as professional engineers and scientists, who comprise only 1 percent of the working population. The managerial group likewise embraces more than the term normally signifies, for it covers clerks, office workers, and service personnel whose jobs do not call for manual productive or operational skills.

In the course of a century, agriculture has steadily lost ground to industry and commerce, and for

75 years the ratio of common labor has dropped—slowly until World War I, but at an increasing tempo since, especially in the years after the establishment of legislative curbs on immigration. Yet the amount of common labor to be performed has not diminished—on the contrary, it has steadily increased. As on the farms, so in industry: mechanization has replaced "strong backs."

Paradoxically, the initial purpose of mechanization was not to fill in gaps created by shortages of unskilled labor, but rather to effect economies through the elimination of workers. Although it started on the farm with the cotton gin and the reaper, mechanization acquired its greatest momentum during the depression, when labor was in surplus. It furnished the thesis for the abortive economic theory of technocracy, first formulated by William Henry Smyth and later promoted by Howard Scott. Despite organized labor's resistance to technological unemployment, which was allegedly produced by mechanization, labor-saving devices were paramount in solving the manpower shortage that appeared in 1937 and that became acute with our entry into World War II.

Except for the brief sags in industrial activity in 1948–49 and 1954, the labor supply has barely been in balance with the nation's needs since 1939. Mechanization has been extended, this time to fill the human gap, and science and engineering have been taxed with the responsibility of carrying mechanization one step farther—to automation. Whereas mechanization replaced several manual laborers with a single skilled machine operator, automation completely dispenses with the human element in certain mechanical operations. One highly trained maintenance man may substitute for hundreds of workers, after skilled technicians have installed the equipment. Again the cry of technological unemployment is being heard. Again we face an even more drastic change in the composition of our labor force. Because future demand will be for fewer "strong backs" and for many more strong brains, it is pertinent to ask whether we can make this change, which contains some revolutionary elements.

A century ago the untutored but mechanically minded genius could easily invent a labor-saving device in almost any field of industry and transportation. Increasing knowledge and specialization rapidly narrowed the field of invention for everyone except the highly trained and experienced engineer, and since the early stages of World War II, the engineer—who has gone as far in some areas as our knowledge of basic science will permit—has found that basic research and its application must evolve concurrently if he is to make further progress in an increasing number of fields. The result of this discovery has been so extraordinary that it has not yet penetrated public consciousness, nor is it fully appreciated by the scientific professions themselves.

Fifty years ago, the proverbial habitat of the scientist was the university classroom and laboratory—the so-called ivory tower. He looked with distrust and disdain upon the engineer, and the feeling was reciprocated. World War I penetrated the barrier between so-called pure and applied science but did not break it. World War II shattered it, but it had been weakened in the interwar period. It was during the 1920's that geologists were asked to apply their science to the search for petroleum, and the petroleum and chemical industries found increasing uses for the knowledge and versatility of university-bred chemists. Whereas in 1915 most geologists and chemists found employment in teaching and in government bureaus and laboratories, nearly three-quarters of them are now in industry. Biologists have shown the strongest resistance to industrial employment, but the lure of discovery in the drug and other organically based industries is proving too much for them, too.

The effects of the expanding industrial requirements for specialized personnel are now well known. Demand has exceeded supply since the early years of World War II. This year, approximately 23,000 engineers were graduated; 35,000 could have been used. The situation in the sciences, although it is more difficult to reduce to statistics because of the attrition among those who have earned only a bachelor's degree, is no better. In both science and engineering, 20,000 men are needed annually for normal replacements, and nearly 35,000 more are required to keep pace with the technological demands of our expanding economy. The need is compounded each year at about 7 percent. Can it be met? If so, how? If not, what will be the consequences?

Long experience acquired by such organizations as the Educational Testing Service has shown that the distribution of "intelligence," or mental ability, among our young people is a constant and that there is little prospect of raising the ratio of the bright to the mediocre. The latter can acquire competence through education and training, but it is virtually impossible to transform them into the capable, creative people who, through scientific discovery and technological development, will push the American economy above its present level. In the quest for brainpower, therefore, we must focus on the quarter of the high-school population that possesses the highest degree of native intelligence.

Concern has recently been expressed because

only half the high-school students who have the mental capacity for higher education actually go to college. For some, financial considerations are the limiting circumstances; but for most, it is a deficiency in motivation. Although any assumption that this entire group should be college-educated is gratuitous, it is an obvious pool of brainpower of which maximum use must be made if we are to maintain the present rate of industrial and economic growth. The complex problem of motivation is clearly an area for immediate research, but even with our present imperfect knowledge it is plain that there will be no simple answer. Sex, racial discrimination, high-school training, social traditions, and environment, as well as money, are involved.

Yet thoughtful research that isolates the multiple facets in motivation is likely to prove rewarding, not only in revealing criteria for the identification of leaders who will maintain the tempo of our national growth, but in delineating the educational needs of the less able. For all the thought that has gone into public education, especially since secondary schooling has become the norm for three-quarters of our young people, at least part of our educational theory was created in a vacuum. It is commonly described as training for life, or life adjustment, but one sometimes marvels at the sheltered lives many of our educational theorists appear to have led. We live in an age of science and technology and under a competitive system. But many of our able youngsters complete high school without any knowledge of science and without the background for higher education; the less able are no better prepared for the competitive life that awaits them in an industrial civilization. Yet to the former we must turn for inventive genius and leadership, and to the latter for the productivity that has given us our pre-eminence among the nations of the world.

We must not, to be sure, prostitute our educational system by converting it to vocationalism, but we should adapt the instruction given in our schools not merely to the environment in which we live but to the one on which our future as a nation depends. Like some of our journalists, advertising agencies, and movie magnates who have cynically geared their products to 12-year-old mentalities, our educators have too often debased elementary and secondary instruction to an assumed common denominator of intelligence as a basic principle in "mass education." The critics of this statement—and there will be many—are invited to study the charges made by the growing number of educators who have become concerned with our neglect of the able students. And even these educators underrate the mental capabilities of the many who, despite mechanization and automation, must do the world's work as skilled or semiskilled workers or technicians. They overlook the historical fact that, within a century, all but 12 percent of our population—and most of them underprivileged—have been educated out of the category of unskilled laborers; that semiskilled workers are growing scarcer, in large part because American industry has discovered a higher mental potential in our human resources than is developed in our schools. It is a strange and paradoxical world in which industry is doing more than education to develop the human potential.

Let us recall that this change in the complexion of American labor has occurred without any demonstrable improvement in native intelligence or in the ratio of the bright to the average. There has, however, been a steadily rising demand for talented people who, in response, have turned out in larger numbers than would have been predicted 50 years ago. In 1900, for example, industry employed but one engineer for every 300 workers. Now it is one for every 60. As recently as 1920, a scant 10 percent of our scientists served industry; now nearly 50 percent are finding new chemical compounds, devising new power plants, thwarting plant pests, discovering oil, or inventing computers. Where has so much talent come from? From our farms, where science and invention have drastically cut the need for manpower, and from our second-generation immigrants, whose fathers had no opportunity to cultivate their brains. If we are concerned that half of the upper quarter of our high-school graduates are not going to college, let us remember that the percentage of our best high-school graduates now entering college has risen steadily since 1900. In fact, the ratio of those now receiving doctor's degrees is not far from the ratio of those who merely earned bachelor's degrees 55 years ago.

Nonetheless, we are short of highly trained personnel in nearly every field, even though a substantially higher proportion of our more capable students are entering institutions of higher learning. Although prediction is hazardous, simple projection of the curve of increasing brainpower utilization across the reservoir of brainpower available reveals the disturbing fact that the need will soon exceed the supply, even on the assumption that everyone in the pool will make himself available. What then? We can still stretch our normal labor supply through more and better education and through automation. We do not have this option, however, in cultivating the brainpower we need to maintain the pace set by our expanding

economy. Unless we wish to stabilize our economy involuntarily at a level determined by the manpower-brainpower ratio—which appears to be a constant—we have but one expedient: we must place increasing dependence on brainpower abroad, not by importing it but by integrating our technology with that of other nations.

International cooperation and integration are, to be sure, temporary expedients, but they appear to be the only ones immediately available. Just as the "underdeveloped" countries are finding their progress retarded by inadequacy of capital and developed energy, so the United States can foresee a finite limit to its human resources and, specifically, to its reservoir of leadership and brainpower. When the limit is reached, the ascending curve of our productivity will level off unless we are prepared to move beyond our national boundaries for human resources as freely as we do now to meet certain of our raw material needs. Imperialism and colonialism are no longer acceptable as means of solving national problems or meeting domestic deficiencies. Hence we must anticipate a new kind of internationalism that transcends the defensive alliances in our present troubled world. This concept of internationalism will involve sharing our strength and our standard of living equally with those allies who are able and willing to help us maintain them.

Manpower and the Economy of the U.S.S.R.

A large population is by itself an economic asset. This proposition is not refuted by the usual reference to the prosperity of some small countries and misery of some large ones, a comparison that only suggests that quantity is by far not the only criterion. But other conditions being equal, a larger population mustering a larger manpower is economically superior to smaller population and manpower. About the same idea can be expressed also in the following form: a national economy, uniting large human and natural resources, is much stronger—in war and in peace—than one in which the same resources are split under several national economies. The Soviet Union's recent history illustrates these almost obvious comments.

The Soviet Union has at its disposal both rich natural resources and vast manpower. But up to the 1930's their utilization was extremely poor. The mighty Russian Empire, with all its splendor and achievements in arts and sciences, was basically a backward agricultural country. The developed resources were meager; the grade of mechanization was low in all sectors of the economy; and the technically trained cadres were trifling for a nation covering one-sixth of the globe. What old Russia needed above all can be expressed in one word: industrialization.

Only late in the 19th century were taken the first resolute steps toward utilizing Russia's rich natural resources, and even then the matter was not steadily pursued. On the eve of World War I, industrial development came in full swing. But it was too late; the inadequacy of Russia from an industrial point of view led to defeat—the event which preceded revolution and communist seizure of power. Through civil war and nationalization, the economy of the U.S.S.R.—particularly the young extracting and manufacturing industries—received a severe blow from which recovery was slow. With the introduction of the 5-year plans, industrialization was rigorously resumed in a new form—ruthless state capitalism that was covered by socialist verbiage about the interests of the working class.

In the early 1930's, industrialization was intimately connected with collectivization of agriculture. Communist terror against well-to-do peasants and famine resulting from enforced collectivism drove millions of peasants to urban centers, where they found employment in industries that developed rapidly with the help of capital investment squeezed out of the rural economy. As mechanization of agriculture progressed (this was the only positive aspect of collectivization) farm manpower requirements were reduced, and such reductions built up new masses of superfluous *kolkhozians* (collective farmers). Despite millions who had perished in connection with collectivization, and even larger numbers who were absorbed by the cities, there was still in 1940 in the *kolkhozes*, according to an official estimate, a surplus labor force of 5 million. This remainder of an inveterate disease—for agrarian overpopulation in Russia dates back to the time before the liberation of the serfs—was liquidated by the huge military and civilian casualties in the war with Germany, combined with a persisting demand of industry for additional hands.

The long-overdue Industrial Revolution took root in Russia more suddenly and subsequently developed at a much faster pace than it did in other Western countries. And since its promoters were totalitarian communists, it lacks some aspects that are considered to be characteristic of the entire Industrial Revolution: the liberation of the individual and the spread of political freedom, both of which are indispensable to engender the required animation of economic activities. Up to now, the experience of the U.S.S.R. seems to refute such a general characteristic and attempts to show

that a regimented economy can be substituted for the incentives offered by the fruit of free individual activity, at least to a certain degree, by growing opportunities for socioeconomic ascent. Whether or not this reversal of the Western experience is temporary or permanent remains to be seen.

Still we meet in the U.S.S.R. the familiar economic-demographic traits of the Industrial Revolution. From the fifth or sixth place occupied up to World War I, the U.S.S.R. has advanced to the position of an industrial world power, second only to the United States. In the short span of the last 30 years, the proportion of the urban population has more than doubled, an increase of from 18 percent to 40 percent of the total population. The number of nonagricultural workers has risen more than 4 times, from 9.5 million to 41 million. The number employed in agriculture has dropped from more than 80 percent to some 40 to 45 percent of the total labor force.

The agricultural population is still extremely high and it represents an enormous mass of about 50 million, whereas in the United States, farming on an area of similar dimensions is done by less than 8 million, who constitute only some 12 percent of the total labor force. The contrast between U.S.S.R. and American figures has given rise to comments emphasizing the enormous waste of manpower in Soviet agriculture. And certainly waste there is, but it should not be exaggerated. The U.S.S.R. requires a much larger agricultural manpower, even under careful use. Despite the dimensions of the surface covered by the Soviet Union, the amount of good arable land is limited, particularly as a consequence of climatic conditions. Excepting the most southern areas, which are largely unsuitable for agriculture, the relative geographic position of the U.S.S.R. is north of the parallel that borders the northern United States; this restricts farm land area. To feed a large and growing population, the U.S.S.R. has been forced to expand cultivation over marginal land. As Huntington and Valkenburg have stated, the U.S.S.R. utilizes agricultural possibilities more fully than the United States. If New England and northern New York were in the Soviet Union, the abandoned farms would undoubtedly be cultivated to yield more than the average Soviet Union yield. True, productivity per man hour is promoted by progressive mechanization. But the machinery the U.S.S.R. has at its disposal does not equal the equipment of American farms. Nor should the figure of 50 million people who work in the fields of the Soviet Union be taken at face value, for what counts is not only their number but also their composition by age and by sex. War losses have particularly affected the male population in the working ages, and in the postwar period industry has continued to siphon off the young male generation from the countryside. Observers have been awed by the masses of women working in the fields who, in addition, do all the menial chores. Indeed, the farm labor force, 50 million strong, includes less than 20 million males in the working ages of 16 through 59. The balance of the force is composed of women, youngsters below 16, and old people (*5*).

The remaining factors responsible for the Soviet Union's superfluous agricultural manpower are lack of know-how and defective organization, in particular the mass of parasitic administrators of socialized agriculture. The slight improvements that are being achieved in this regard and the steady increase in mechanization have tended to reduce the manpower requirements for food and other agricultural production. The rural population, therefore, certainly will continue to function as a reservoir from which expanding industry draws additional manpower. The process goes on in two ways. One is rural-urban migration of adults looking for employment. The other is recruitment of boys and girls in the ages of 14 to 17 for training in factory, handicraft, and railway schools. Altogether, industrialization attracts to the cities a number of migrants equivalent to the entire natural increase of the rural population.

Industrial development has been the prime mover behind the rapid pace of urbanization which, in its turn, has had grave demographic repercussions. Once the peasants were in the cities, their high levels of fertility and mortality began to change—to be shaped by the new urban environment that included not only educational and related opportunities but also better medical facilities and notions about birth control as well as incentives to use them. Although the rural population experienced the consequences of industrialization much less intensely than the city dwellers did, to some extent educational and medical facilities also have been provided in rural areas. And here, too, rationalization of procreation has gained ground, the decrease of fertility being stimulated also by an inadequate number of males in procreative ages.

By the eve of World War II, in the relatively short period of 25 years after World War I, the Soviet Union had almost completed what is known as the "demographic transition." It had passed from a period of very high birth and death rates to one in which the death rate was relatively low while the birth rate, although declining too, remained high. After the end of World War II the

trend was resumed, and recently the final stage of the demographic transition has set in. The death rate has reached such a low level that a further decrease will be very difficult to achieve, and the birth rate has fallen at a more rapid pace than the death rate. In other words, the natural rate of increase of the population, although still high, has been slowing down.

These demographic changes, however, although they are of great consequence for the future, will not at once be reflected in the size of the labor force of the U.S.S.R. At present, large age cohorts are still entering the labor market—those born after the famine caused by collectivization was already over. Only after 1960 will the birth deficit of the war years become fully apparent in reduced cohorts of young workers. These cohorts will be followed by the relatively normal postwar cohorts who reflect a much higher, although decreasing, fertility.

To summarize a quantitative approach, the human resources of the Soviet Union are adequate for the requirements of the economy; no deterioration is visible in the immediate future, particularly since progress in agriculture will continue to release manpower. True, in the last 3 years, to meet increased demands for food, contingents of urban workers have been directed to Kazakstan and other regions where reclamation of virgin lands is in process. The number of these urban-rural migrants, however, is relatively small—hardly more than 50,000 a year. It is rather their qualification as mechanics and other specialists that makes their cooperation valuable and their moving noticeable. But here we touch the qualitative aspect of U.S.S.R. manpower.

The approach to the question of the qualitative strength of the Soviet Union's manpower usually oscillates between two extremes. One is condescending underevaluation — Western civilization technically equipped and based on scientific reasoning against a traditionally half-barbaric Slavic Orient. This approach lulls us into security, whatever might be the numerical strength of Soviet Union manpower. The other extreme, which recently has become more and more prevalent, is that of an excessive overestimation of achievements and possibilities. A sober analysis rejects both extremes not only because they are defective as are almost all extremes but also because they are products of superficial generalization.

The U.S.S.R. is a land of contrasts, of modern skyscrapers and miserable huts, of almost perfect machinery and primitive implements, of grandiose technological progress and scarcity of the most simple and the most necessary things. By way of example, an anecdote circulating in the Soviet Union ridicules a propagandist who extolls Soviet achievements. The Americans, the propagandist says, boast of having so many cars; but communist industry will soon provide every citizen of the U.S.S.R. with his own airplane. When someone in the audience interjects, "What do I use it for?" the speaker explains: "Suppose you have holes in your socks, but you cannot get a needle to mend them. Now you are told that needles are being sold in Kharkov. You take your plane, fly to Kharkov, and the same day you bring home a full dozen needles, and your wife can mend the socks." The moral of the anecdote, of course, relates to a serious economic problem. Concentrating on military requirements, means of production, and some other objectives, the manufacturing industries of the U.S.S.R. are unable to cover even minimal demands for housing, household goods, and other consumer items. One reason for this situation is capital shortage. Another is a shortage of adequate manpower. But where is this shortage located? It has been noted that U.S.S.R. industry has a sufficient supply of unskilled labor. But what about the ranks of skilled labor and the professions?

According to Lenin's famous statement made immediately after the Communist seizure of power, every charwoman would be qualified to govern the nation and to administer its affairs. The Communist leaders themselves have been of diverse educational levels. But to administer the economy of the U.S.S.R. and to develop natural resources, they relied not on the charwomen but on the old Russian specialists and the new cadres trained by them.

The Soviet Union's views concerning old Russia went through two stages. At first the communists painted everything prerevolutionary in black, presenting whatever there was valuable in the Soviet Union as socialist achievement. Then, reversing their attitude, they arrogated Russia's past as a forerunner of the Soviet Union's glory, and in an extremely ridiculous way claimed priority in any scientific discovery or technological invention. In rejecting the nonsense of Soviet propaganda, however, it should be recognized that old Russia's achievements were great not only in arts but also in the sciences. In particular, in the atomic age, it is only fair to remember the name of Mendeleev, author of the periodic table of the elements, on whose teachings the doctrine of the atom was based for several decades.

The Soviet Union inherited the Russian intelligentsia, whose intellectual and moral standing was very high. The communist rulers persecuted individual scholars and technicians for political reasons and probably corrupted a great number of

them. But they have been eager to preserve and develop their scholarly and technical abilities. Only in a few places in the world does the scholar as well as the artist enjoy such a privileged material position as he does in the Soviet Union, albeit they remain, like all Soviet peoples, slaves of the communist dictators. In general, learning is parallel to Communist party activity; it is the main road to Soviet "prosperity." As such, it attracts the Soviet youth in ever growing numbers, especially toward science and technology. The number of professionals in higher education is impressive, even if it is compared with that of the United States. There are some 540,000 engineers in the Soviet Union against about 560,000 in the United States (the Soviet figure also includes architects); 337,000 physicians and other personnel in the medical field against about 400,000 in this field in the United States; and approximately 857,000 persons with college degrees in education against some 1,300,000 in the United States. Still more impressive is the growth of the number of professionals in the U.S.S.R. Since 1940, the number of engineers has almost doubled. The same growth applies to the agricultural and socioeconomic fields, while the numbers of physicians and teachers has nearly tripled. And, as experts attest, this quantitative gain has come by no means at the cost of quality.

It should be noted that the U.S.S.R. has a fair and rapidly increasing number of scholars and professionals at the higher levels and a sufficient reservoir of unskilled labor at the lower levels. In the middle layer, however, is found the Soviet Union's shortage of manpower. This shortage is noticeable when we go from the professional labor force to the semiprofessional; and still more serious are the insufficient numbers of skilled workers. This, too, is an inheritance from old Russia. Even when the Russian economy required only 1 million or so skilled workers, they were not available. There is not a sufficient supply of this type of labor now when the U.S.S.R. needs some 20 or 30 million of them. And there are other areas than manufacturing in need of skilled labor. Moscow propagandists boast that the Soviet Union uses the most modern machinery in all sectors of the national economy. Even if we make allowances for exaggeration, the demand for trained mechanics to handle machinery is certainly very great. The use of manpower in the *kolkhozes* can be curtailed only by use of agricultural machinery that is operated by skilled workers. As has been noted, the expansion of the agricultural areas depends too on the problem of skilled handlers of farm equipment. In addition, in the Armed Forces, almost every soldier must be a technician of some kind.

The Government of the U.S.S.R. is attempting to meet this demand for skilled labor. Trade, railroad, mining, and factory schools turn out 300 to 350 thousand graduates yearly. But we may well be skeptical when we are told that, in addition to these boys and girls, the "qualifications" of 7 million factory and office workers were "raised" in 1950 by means of individual and brigade apprenticeship and course training, and that again three years later 7.7 million workers altered their qualifications or received instruction. To speak of "raising qualifications" can mean anything. That which certainly has been raised is the foundation of technical progress—the level of general education. The entire youth is enrolled in the 7-year school course, and expansion to a general 10-year school is under way. But despite all the efforts of the government and despite the substantial achievements that cannot be denied, the shortages of skilled workers remains a weak point in the economy of the Soviet Union.

Here lies the explanation of so many achievements and shortcomings in the U.S.S.R. The Soviet Union can reach the summits in atomic weapons production or in airplane building because there are outstanding scientists and technological inventors in the nation and because it can supply these privileged industries with the required amount of skilled labor. But it can not do the same in all sectors of industry. This explains—apart from the capital investment problem—why spectacular achievements go hand in hand with the most primitive conditions of life in the Soviet Union.

References and Notes

1. K. von Clausewitz, *On War*, translated by Graham and Maude (London, 1918), Book 8, Chap. 6B.
2. Strategy is used here as E. M. Earle uses it in *Makers of Modern Strategy*. Up to the end of the 18th century, strategy was merely a body of stratagems and tricks (*ruse-de-guerre*) to deceive the enemy and win victory. "But," Earle states, "as war and society become more complicated, . . . strategy of necessity has required increasing consideration of non-military factors —economic, psychological, moral, political, and technological" (p. viii). Strategy is not merely a concept for wartime, therefore, but an element inherent in statecraft at all times (Earle).
3. For further reference see: U.S. Director of Selective Service (Lewis B. Hershey), *Selective Service in Wartime*, Ed. E. A. Fitzpatrick (Government Printing Office, Washington, 1943).
4. E. A. Fitzpatrick, *Universal Military Training* (McGraw-Hill, New York, 1945).

4*a*. Condensed from the original statement.

5. At a recent reception for the U.S. Farm Delegation in Moscow, the Minister of Sovkhozes, Benediktov, announced a figure of 27 million "able-bodied" workers in the *kolkhozes, sovkhozes* (state farms), and machine tractor stations.

Future of Atomic Energy

JOHN COCKCROFT

Sir John Cockcroft has been director of the United Kingdom Atomic Energy Research Establishment at Harwell since 1946. From 1944 to 1946 he was director of the Montreal and Chalk River Laboratory of the National Research Council of Canada. This article is based on a lecture that was given on the evening of 19 August 1955 at Geneva, Switzerland, during the United Nations International Conference on the Peaceful Uses of Atomic Energy.

TO many of us, the Geneva International Conference on the Peaceful Uses of Atomic Energy was a celebration of a very great achievement of the scientific world—the harnessing of the energy of atomic nuclei to serve the future needs of man. This achievement is the culmination of scientific work of men of genius in many nations. It is fitting therefore that representatives of the great majority of countries should have come together to present their contributions to this work and to discuss how this new source of power can help the future development of their individual countries and the whole human race.

We had described to us the first experimental atomic power stations and we heard that they are working well. We also heard of the rapid progress in construction of the first full-scale nuclear power stations. Within 2 years, they will be delivering very substantial amounts of electricity to industry, and we will begin to gain experience in their operation and economics. These early stations will be closely followed by successors of different and generally improved designs, and within 5 years we are likely to have at least ten nuclear power stations operating in different parts of the world and generating up to 200 megawatts in a single unit.

These will all be pioneering or demonstration stations built to test the technology on which all depends and to compare the relative advantages of the ten most promising types both from the point of view of economics and also from the point of view of reliability and safety in operation. Thus most of the next decade will be occupied in laying a sound basis from which nuclear power can expand rapidly to become in the end the major power source of the world. Until we have achieved satisfactory operating experience, we will not be justified in embarking on a more rapid expansion.

This new industrial development has the advantage of a very great and unparalleled concentration of scientific and engineering ability driving it forward with imagination and enthusiasm—as one can judge from the papers that were presented to the Geneva Conference. For this reason, the speed of development will be rapid, and the nuclear power stations of 1970 will look as different from those of 1957 as the modern motor car differs from the Model T Ford.

The papers presented at the conference showed that we must not expect the cost of nuclear power to be cheaper in the next decade than power from coal. The consensus was that capital costs will be appreciably higher—50 to 100 percent higher—than the capital costs of coal stations, but that fuel costs will be less than half those for coal. Therefore, on balance, there should be little in the cost of power, with nuclear power slightly more expensive than conventional power.

But to many countries this is not the important point. The important point is to obtain an additional source of energy to supplement conventional energy resources wherever they are becoming overstrained.

Nevertheless, the whole history of engineering development shows how rapidly capital costs fall in the early stages of important new developments, and there is good reason to believe that in the second decade the cost of nuclear power will fall below that of power from coal and oil.

The second major objective is progressively to increase the amount of energy that we can extract from each ton of uranium and thorium. We believe, although we have not yet proved the point, that in the early stages we can extract from 1 ton of uranium the heat equivalent of about 10,000 tons of coal in a single fuel cycle; but we also heard of the promise of recycling the fuel in thermal reactors several times so that the energy extraction can be increased five- or tenfold. We also heard of the more ambitious final goal of achieving the nuclear physicist's dream of making use of the breeding principle and extracting a great part of the fission energy of the whole uranium. In this way, we expect to make 1 ton of uranium do the work of at least 1 million tons of coal. The engineer has still to convert the physicist's dream into large-scale practical power stations, but we heard during the conference of the building of large-

scale experimental breeder reactors both of the homogeneous and fast-neutron types. Both types have their difficult engineering problems, but sometime during the second decade breeding is likely to be an important characteristic of nuclear power stations.

General Applications

Economists and statisticians looked ahead to the years 1975 and 2000 and they predicted that by these years our energy requirements will increase by at least 1½ times in 1975 and by 3 times in the year 2000. So by the end of the century the world is likely to require the energy equivalent of 7000 or 8000 million tons of coal a year as compared with our present usage of 1700 million tons a year. Almost one-half of this energy will be required for generating electricity. Hydroelectricity should by then be fully developed, but even so, it will do the work of only 1000 million tons of coal a year. It will be of great help to the human race if by the year 2000 nuclear energy can generate the remainder of the electricity and so do the work of 2000 to 3000 million tons of coal a year.

We heard the forecast of uranium supply—how it occurs throughout the world, not only in concentrated deposits but also in abundant gold ores, shales, and phosphate rocks. In seven countries alone, there is reported to be available at least 1 million tons of uranium, and it was predicted that the costs of uranium toward the end of the next decade will be as low as $10 a pound. The evidence presented to the conference suggests that in the 1960's there will be more than enough uranium for the nuclear power development of that decade. If we look further ahead and combine the forecast of nuclear energy produced in the year 2000 with the forecast of the achievement of breeding, we can see at once that only a few thousand tons of uranium or thorium a year would be required for this task. Hence there would appear to be ample uranium and thorium available to accept the economists' predicted task and if necessary to do even more than this—that is, to carry a still greater share of the world's energy needs until we achieve our final goal and produce by fusion reactions in the *light* elements an inexhaustible power source for the world.

If we look into the middle distance—the 1970's—we see that the use of nuclear power is likely to vary greatly from nation to nation. Some countries such as Norway that are blessed by abundant and cheap hydroelectric power will still be developing these resources as their primary source of energy. Many other nations such as France, Italy, Portugal, and Sweden, where substantial hydroelectric resources are available, will by then have completed this development and will be turning to nuclear power.

Great Britain, on the other hand, is an example of a highly industrialized country with small hydroelectric resources, with poor prospects of any substantial increase in coal production, and with a rapidly increasing demand for electricity and other forms of energy. Therefore, early nuclear power development is essential for Britain—it comes only just in time for us—and we believe that by 1975 almost half our electricity will be developed from nuclear energy.

The United States presents a different picture of a great industrial country with very great reserves of easily worked coal. Their speakers said that the use of nuclear energy in the United States will depend mainly on its costs relative to power from coal. They think that by 1975 the production of power generated from nuclear energy will be between 1 and 15 percent of the total power generated, depending on whether costs are 9 mils a unit or 6 mils a unit. The Canadian position seems to be very similar.

The situation in the so-called "underdeveloped" countries is different again. India is a typical example of an "underdeveloped country" because its real income per head is only one-tenth of that of Britain. It seems also that India's energy consumption per head is in the same proportion. Homi J. Bhabha, chairman of the Atomic Energy Commission of India, pointed out that 80 percent of India's energy comes from the burning of dung that would no doubt be better used for increasing the productivity of agriculture. The production of electricity per head in India is at present one-eightieth of that in Britain, but it is now planned to increase it sevenfold by 1975. Electric-generating capacity will therefore have to increase from 3½ million to 25 million kilowatts installed by that time. The potential hydroelectric capacity is about 35 million kilowatts. This would be exhausted in the succeeding decade. Bhabha said that, since the capital cost of hydroelectric development is likely to be less than that of nuclear power development, the most important part of the electrification will initially be carried by hydroelectricity. On the other hand, nuclear energy will have a specific role to play in areas where hydroelectric development is likely to be slow because it must be combined with irrigation plans that require very large capital expenditure. There are also special areas in India where the construction of thermal stations is at present justified. This part of the load may in the future be taken by nuclear power stations, par-

Calder Hall Power Station at Cumberland, England. The large building is the turbine house and in the background, surrounded by scaffolding, is one of the graphite-moderated thermal reactors. On the left is one of the 80-foot heat exchangers (or boilers) erected on its pedestal. [Courtesy British Information Services]

ticularly where cost of transport of coal is very high.

The development of such countries depends a good deal on the availability of capital resources. Nuclear power may therefore have some special advantages when capital costs of reactors fall, because its use avoids heavy capital expenditure on coal mines and on special facilities for transport of fuel. Nevertheless, we must recognize that nuclear energy by itself is not a magic key to prosperity for underdeveloped countries. The main requirements are the provision of capital and the development of the technology and agriculture of these countries. Nuclear energy will insure that sufficient energy is available to allow these developments to take place.

Special Applications

Besides these general aids to development, nuclear energy may have a special part to play in some regions. One of these may be in the development of arid zones. For example, one-third of the power used in Israel today is devoted to irrigation —for pumping water—and Israel is planning a fourfold increase in irrigated areas in the next decade. The uranium in their phosphate rocks should be very important in providing fuel for this increased pumping power.

B. F. J. Schonland suggested that in southern Africa the semiarid Karoo could become a well-watered region if the waters of the swamps of northern Bechuanaland could be pumped to the Karoo. Nuclear power may help.

M. L. E. Oliphant suggested that the tropical parts of Australia, particularly the central and western areas, could support much higher populations if life there could be made more attractive and work be made more efficient by a widespread adoption of air conditioning. This has already been shown to have a marked effect in other tropical countries. These areas are remote from sources of fossil fuels and are short of water. Here, then, is a role for the "packaged reactor" that drives gas turbines, since gas turbines do not require large amounts of cooling water. It seems likely that reactors producing power in blocks of about 10,000 kilowatts will have important applications in remote areas and underdeveloped areas.

It seems also that recent developments in the demineralization of sea water offer prospects that nuclear power may one day be used to produce large quantities of fresh water from the sea at a reasonable cost for waterless areas near the sea such as South-West Africa.

Nuclear energy will have another special role to play in providing power for industrial and mining areas remote from coal mines and hydroelectric supplies. In South Africa, coal from the Transvaal and Natal has to be transported to the Cape by an already overloaded railway system over a distance of 1000 miles, so that the cost of power is twice that at the source of coal and is about 0.8d. per unit. In the Federation of Rhodesia and Nyasaland, coal is transported from Wankie about 500 miles over an overloaded railway system to the copper mines of Northern Rhodesia. By 1962 the Rhodesias will need 4 million tons of coal a year for power generation alone, and this is the whole predicted output of the mines at that date. Some help will indeed come from the hydroelectric development of the Kariba Gorge, but this is 250 to 300 miles from the mines, and transmission costs are likely to be abnormally high and will double the cost of power at the source. Therefore, Schonland suggests that, by the 1970's, nuclear power stations of considerable size—perhaps up to 1000 megawatts—could be contemplated in the copper belt itself. By this time, nuclear power is likely to be important also at the Cape.

There are many other regions in the world where mines are remote from fuel sources. Thus in Canada the present cost of diesel-generated power at Port Radium and Beaver Lodge is 4 times the normal cost. Similar cost levels prevail in mining areas of Australia such as Broken Hill. The local application of nuclear power should encourage the production at the mine itself of highly refined metals by electrolytic and electrothermal processes. In this case, capital investment might be diverted

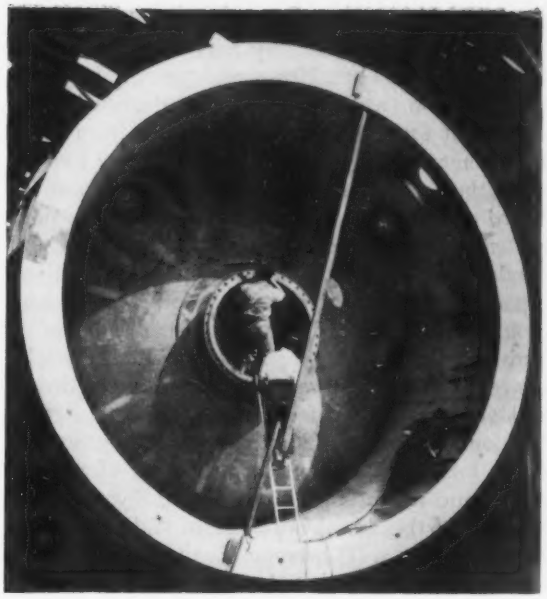
from the building of railway systems to carry coal to mining areas and ores and crude metal products back to industrial areas; instead, the capital might be used for nuclear power units. Nuclear power units for such areas would have to be built in a transportable form and would probably have to use enriched fuel with provision for some regeneration of fuel. Such units could probably be built within 5 years to produce power at about twice the cost of power from full-scale stations. In such areas however, these costs would be acceptable.

There are other processing industries, such as cement, pulp, or paper that are often located away from fuel sources where energy is required in the form of high-temperature heat. Reactors producing high-temperature gas might be developed for such purposes.

Industries such as aluminum could absorb the output of the largest scale nuclear power plants now contemplated. These plants may produce power at costs well below that for coal stations in the second decade, but they are unlikely to compete with the lowest cost hydro power. Nevertheless, in the long run their use may lead to large-scale shifts in the location of metallurgical industries.

We did not discuss in the conference the possible application of atomic energy to transportation which today consumes about 8 percent of the energy of the world. The United States has already shown that the nuclear propulsion of ships is technically feasible, but only a limited amount of information on the economics of nuclear propulsion is available. A fairly recent discussion in the United States Congressional Committee suggested that present nuclear propulsion systems would lead to costs about 10 times normal commercial costs. On quite general grounds, it would appear that commercial nuclear propulsion of ships is not likely to be developed until the cost of heat energy from pure fissionable material is less than that of fuel oil at £6 per ton. This obviously requires that plutonium or uranium-233 should become available as a by-product of reactor operations at a cost of appreciably less than £6 per gram. Regeneration of fuel and high burn-up in fuel elements will help. Thus, if plutonium becomes available at £3 per gram, and 50 percent burn-up and 33 percent thermal efficiency are achieved, this would lead to fuel costs of 0.3d. per kilowatt hour, which would be commercially interesting.

It seems quite possible that these conditions will be reached by the time large-scale breeding is achieved. But many other technical considerations have to be taken into account in determining the desirability of commercial nuclear ship propulsion. The engineers responsible must in particular be especially concerned with the potential hazards of leaks of radioactivity in such confined quarters. For such reasons I do not myself predict a rapid development of commercial nuclear propulsion.



The end of one of the 80-foot heat exchangers (or boilers) being assembled on the site of the Calder Hall Power Station in Cumberland. There are four of these boilers to each atomic pile and in them will be created the steam that will run the generating plant. [Courtesy British Information Services]

In the present state of nuclear technology, chemical and metallurgical operations play a major part, and their role is likely to become more important as we progress toward the development of breeding, for by then nuclear fuel costs will be due almost entirely to chemical processing costs. Some of the homogeneous nuclear power plants of the future may indeed be chemical plants of highly specialized nature. Even with solid fuel reactors, there are considerable possibilities for reducing recycling costs by simpler processes in which some of the important radioactive waste products that poison the chain reaction are removed without dissolving the fuel elements in acids or solvents. Since the spent fuel elements will be highly radioactive, remotely controlled operations will be necessary—here is a good application for the automatic factory.

Fission Products

The development of nuclear energy will inevitably lead to the production of large quantities of radioactive fission products. At present, these prod-

ucts are looked upon as a nuisance and a problem for the future because they have to be stored for long periods of time. However, it seems likely that the radiation from these waste products will find important uses. The gamma radiation from spent fuel elements can be used in the first few months after their withdrawal from the reactor, and we heard of several such applications. Our discussions on waste disposal showed that the long-lived useful products radiocesium and radiostrontium will be separated from the rest of the fission products and concentrated into radioactive sources. The radioactivity of the remaining fission products will be concentrated and stored until the activity decays to low enough levels for discharge into the sea or fixation. The cost of this storage has been estimated to be less than 2 percent of the cost of nuclear power and will probably be offset by revenue from the sale of the useful radiocesium and radiostrontium, which will become available in source strength varying from kilocurie sources of radiocesium for radiotherapy and megacurie sources for industrial applications.

Work on the application of radiation needs to be pursued on a much wider front before its possibilities can be properly evaluated. It already seems certain that sterilization of pharmaceuticals and some medical supplies could be carried out with safety as soon as processed fission products are made available in quantity. The sterilization of food has already been strikingly demonstrated, but the processes require much further study and trial before it can be certain that they are acceptable and safe for general use.

An extremely promising field of application of radiation is in insect control. Successful large-scale experiments have been reported from the United States on the eradication of the screw-worm by the liberation of large numbers of males that had been rendered infertile by suitable doses of gamma radiation. In the conference, we also heard of the control of the parasitic disease trichinosis that is transmitted by larvae in pork. Irradiation of hog carcasses sterilizes the female and breaks the disease cycle. In Great Britain, joint studies by the Forest Products Research Laboratory and the Atomic Energy Authority have shown that the life of insects infesting wood can be markedly shortened and their ability to lay fertile eggs prevented by doses much smaller than those needed to kill the beetles and larvae (*Lyctus* species). The eggs of the deathwatch beetle are rendered infertile by doses of a few thousand roentgens. The preservation of historic timber and valuable furniture is an exciting possibility. Entomologists ought to look for other applications in this field.

Chemical synthesis is an application that could use large quantities of fission products. It is accepted that chain reactions offer the best hope of economical utilization. The fields of polymer modification and polymerization have been studied actively. The very high conversion rates observed in some emulsion polymerizations should be noted. Halogenation and oxidation have been relatively neglected. It is not to be expected that industry will set aside well-established processes unless the use of radiation offers some well-marked advantage. Too much current effort is devoted to existing fields of production. In Great Britain, industry is studying such fields with a view to improvements and new products. We are also sponsoring basic research in radiation chemistry and less profound studies in the organic chemistry field. The irradiation of concentrated solutions, nonaqueous solvents, new approaches to chlorination, and molecular rearrangements are being studied. Clear selective reactions of decomposition and oxidation have been revealed, and high yields suggestive of chain processes have been observed in unexpected places. New pathways in sugar synthesis and degradation have been found, but it is too early to say that economic application is proved. The systematic study of organic radiation chemistry is still in its infancy, but it seems to offer the best hope of progress. Radiation may also be applied in the future to the fixation of nitrogen if it becomes really plentiful and cheap.

George de Hevesy spoke in his evening lecture of the important part that radioactive elements are playing in the development of our knowledge of living organisms. I believe that this will be a major contribution to the development of our understanding of the biological world and that this in turn will inevitably contribute to human health and well-being.

Safety

In planning the development of nuclear energy during the next two decades, we have a great responsibility to see that it is developed in such a way that it is an essentially safe industry and that it does not produce a substantial new hazard to the general population of the world.

We have been fortunate so far in having been able from the beginning to lay a sound scientific basis for health protection by the devoted labors of our biologists and health physicists. I do not think that any other new industry has had the advantages of such preparation. The immediate effect of radiation on living organisms has been studied by very large numbers of experiments on animals;

as a result of this, the International Commission on Radiological Protection has prepared a list of safe levels of radiation and of the amounts of radioactive materials that can be ingested. These recommendations have been incorporated into the working practice of all well-run atomic energy organizations and should form the basis of world-wide codes of practice to be promulgated by the World Health Organization.

We have also a responsibility to the general public in our own countries in seeing to it that possible accidents to reactors cannot produce an appreciable hazard to surrounding populations. Here again, codes of practice are being drawn up by experts who really know the hazards and the problems of control. The next step is to compare experiences and ideas of different countries and to agree on international codes of practice. While we are accumulating experience of reactor operation, much can be done to reduce these risks by adopting a policy of enclosing reactors in buildings that are so constructed that they could contain any large-scale leakages of radioactivity that resulted from a reactor accident.

The still larger problem of the long-term effects of raising the world-wide level of radiation by the dispersal of fission products was discussed in the chemical and biological sessions. Our knowledge of the genetic effects of radiation on human beings is at present much less than our knowledge of the effects on animals, and we should press on with research on human genetics and in the meantime adopt a cautious policy. We have some yardstick to guide us in the general background level of radiation due to cosmic rays, potassium in our blood, and radium in the walls of our houses and in the ground. These sources give us all a radiation dose during our reproductive period varying from about 3 to 6 roentgens, depending on the locality. Investigations are proceeding in Britain and the United States by committees of the Medical Research Council and National Academy of Science that should help us to decide by how much the general background level of radioactivity may be allowed to increase without appreciable harm. This may well be followed by international discussion of the problem. We may then hope to prepare international codes of practice that will determine the amounts of radioactive gases that may be safely discharged into the atmosphere and of radioactive liquids and solids that may be safely discharged into the ocean.

I am quite sure that by such means we can carry out this great new development in a far safer way than has been the case in any other new activity of the human race.

International Cooperation

International cooperation can help in speeding up this vital new development. Atomic energy by its world-wide effects in the field of public health can for this reason alone benefit by international cooperation.

We must also not lose sight of the fact that its products—the fissile elements—are potentially very dangerous materials, not only to public health but also because of their explosive possibilities. International cooperation in preventing the diversion of such materials to explosive uses could therefore be of the greatest importance.

In western Europe, we have made a beginning in a modest way in the European Atomic Energy Society in discussing our common scientific and technical problems, and this has already proved to be valuable.

The United Nations Organization is in the process of giving birth to a much more ambitious offspring—the International Atomic Energy Agency. We must all hope that its birth will not be too painful or too long delayed. The agency, wisely guided, could do a great deal to insure that the inherent dangers in our development are prevented.

Having looked into the cloudy crystal ball with my imperfect eyes, I feel quite sure that the real picture 25 years hence will be very different, for scientific and technologic progress is today so rapid that our predictions must be subject to great uncertainties. Rutherford in 1937 could not predict fission and did not believe that nuclear power was likely. Now power from fission reactions is assured. I would like to be able to predict when the exciting prospect of power from fusion reactions will be achieved. But, although we are working seriously on this problem in Britain, my vision is not good enough for that. However, my faith in the creative ability of the scientist is so great that I am sure that this will be achieved long before it is essential for man's needs.

We must all hope that the statesmen who control our destinies and whose vision made the Geneva conference possible will continue to liberate the creative ability of the scientific world and so enable it to produce the benefits that I have so imperfectly attempted to predict.

BOOK REVIEWS

Adaptive Human Fertility. Paul S. Henshaw. Blakiston Div., McGraw-Hill, New York–London, 1955. xii + 322 pp. Illus. $5.50.

Our world population is now 2.5 billion. It is larger and growing faster than ever before. While the present annual rate of increase of the world population is approximately 1 percent, the figure seems more dramatic when it is stated in absolute numbers as well as the rate at which births occur. Julian Huxley in 1948 summarized the annual rate of increase quite interestingly: "It means an increase of twenty-two million people in each year—three every two seconds or so. Translated into terms of days it means that every 24 hours there are about 60,000 more people in the world—the population of a good-sized town. Monday, Wheeling, West Virginia; Tuesday, Cedar Rapids, Iowa; Wednesday, Beaumont, Texas; Thursday . . . , and so on throughout the 365 days." These facts give considerable strength to the author's basic question, "Is the increase in number of people too rapid, and if so, what sensible steps can be taken?"

Giving considerable thought to this question, the author opens his stimulating book with a chapter on "Procreation," including sections on the various aspects of the history and biology of reproduction. This approach prepares the reader for a better understanding of his chapter on the "Growth mechanism" in which he astutely describes the biotic potential law:

$$RPI = \frac{RR}{ER}$$

where *RPI* is the rate of population increase, *RR* the reproductive rate, and *ER* the environmental resistance. It is now generally known that populations vary with respect to two factors: (i) the normal reproductive rate of the particular species when the environment places no restraint on reproduction; and (ii) various environmental factors that combine to retard the normal reproductive process. That these factors regulate the growth of world population is demonstrated in the population curves established by Pearl and the data supplied in the United Nations *Demographic Yearbook*, 1953. Since it appears obvious from the available data that the world population will double in 58 years, it is small wonder that Paul Henshaw appears so concerned about *Adaptive Human Fertility*.

The author makes a very strong plea for a plan of family size. Emphatically, he states: "(1) . . . that serious difficulties are arising as a consequence of man's growth in numbers; (2) that effective fertility guidance is essential if social degradation and spreading poverty are to be avoided; and (3) that to a considerable degree, man's destiny will be determined by his ability to achieve a satisfactory relationship between his reproductive powers and his skill in developing and distributing the materials necessary for life."

The crowning achievement of the book is observed in the last two chapters: "A plan of management" and "The period ahead." In the former, he refers to his plan as *Teleogenesis*. The so-called "teleogenic plan" consists of (i) *providing suitable means of fertility control;* (ii) *instructing* [italics are mine] everyone on the full meaning of responsible parenthood; and (iii) the inherent good judgment and the natural desire of people to keep family size in balance with the proper means of support. The author states that teleogenesis is in keeping with the important tenets of democracy and Christianity. In "The period ahead" the main theme of the book obtains a spire of meaning: "The period ahead . . . will be characterized mainly by a contest of ideologies. . . . Such a contest is not won by force, funds, or voting strength, but rather by mutual respect and concern. . . ." Our concern might well begin with serious thought about fertility.

I thoroughly enjoyed reading this book, and I am certain that it will be very useful to students in demography, sociology, and biology. The author has performed a most commendable job in writing on what most people consider a very difficult subject.

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General Chemistry. L. E. Steiner and J. A. Campbell. Macmillan, New York, 1955. x + 673 pp. Illus. $6.50.

There are a very large number of textbooks for first-year college chemistry. Here is a book that should take a place with the best of them.

The laws, theories, and concepts that underlie chemistry are well presented. The balance between theoretical and descriptive matter, as well as the selection of material from the various fields of chemistry, is well done. The book includes much inorganic chemistry but, as the name implies, it also deals with general chemistry. There is adequate material to satisfy the better student and it contains enough flexibility to meet the requirements of most teachers.

The authors state in the preface that the subject matter ". . . is tied together by continual emphasis on the interpretation of properties and reactions in terms of structural relationships." An outstanding feature throughout the book is the skill with which this has been accomplished. The structural diagrams are adequate in number and, in general, exceptionally well done.

The exercises and problems with each chapter constitute an important part of the text. They seem to be designed to encourage thinking on the part of the student. The inclusion of answers to at least some of the numerical problems would probably have been helpful to the average student.

The physical make-up of the book is good. The index seems to be adequate.

E. LEE GAMBLE

Massachusetts Institute of Technology

The Underwater Naturalist. Pierre de Latil. Edward Fitzgerald, trans. Houghton Mifflin, Boston, 1955. 275 pp. Illus. + plates. $3.50.

After all the books about the joys of plunging into the aquamarine world, with their often disparaging comments about what the scientists say of this or that fish and their apothegms to Neptune, it is a pleasure to call the reader's attention to a literate, urbane book about fishes, as known by both the ichthyologist and the diver. The locale is the coast of southern France, especially around Nice, but the author has written a book for everyone interested in diving and fish anywhere.

A few more books like this, and we will begin to think that aqua-lunging is really a useful means of obtaining biological information after all. Of course, it must be understood that Pierre de Latil is an accomplished author with several excellent books on marine life to his credit, and that his book has been well translated. He is casually familiar with the Romans and the great ichthyologists, and his chapter on the "morays" is a delightful debunking of a gruesome Roman custom. There is also a great deal of original information on the behavior and habits of fishes, which makes the book essential to ichthyologists, as well as an example for other hopeful divers who write books to "go thou and do likewise."

JOEL W. HEDGPETH

Scripps Institution of Oceanography

Volume Jubilaire, Victor Van Straelen, Directeur de l'Institut Royal des Sciences Naturelles de Belgique, 1925–1954. vols. I and II. Institut Royal des Sciences Naturelles de Belgique, Brussels, 1954. vi + 1213 pp. Illus. + plates.

These two large volumes have been prepared as a tribute to Victor Van Straelen on the occasion of his retirement as director of the Institut Royal des Sciences Naturelles de Belgique. The staff of the institute has contributed papers to make up these volumes, and, since it was intended to show the scope of the institute's activities, the subject matter included is diverse. The first volume contains a brief foreword and sections devoted to mineralogy, paleobotany, and paleontology; the second is devoted to zoology with the exception of one paper on the education service department of the institute. As would be expected, nearly all the papers are concerned with subjects that occur in Belgium or its colonies. The scope of the papers varies considerably: some are limited to one or two species, some are taxonomic discussions of large groups, and some are discussions of ecologic associations.

It is beyond my competence to analyze critically all the material contained in these two volumes, but it may be of interest to indicate some of the subjects treated. The first volume contains, in the section on mineralogy, a paper on sedimentary petrology of the Carboniferous period and a paper on the occurrence of arsenopyrite in the Brabant; in the section on paleobotany, a paper on Carboniferous and one on Pleistocene floras; in the section on paleontology, ten papers dealing with Devonian, Carboniferous, and Tertiary faunas as well as taxonomic studies of various groups. The second volume, primarily on zoology, contains papers on the following subjects: siphonophores, annelids, gastropods, crustaceans, arachnids, insects, reptiles, birds, anthropoids, and general papers on anthropology and ecology. The format of the volumes is excellent, and the illustrations are generally good.

JEAN M. BERDAN

U.S. Geological Survey

Salamanders and Other Wonders. Still more adventures of a romantic naturalist. Willy Ley. Viking Press, New York, 1955. x + 293 pp. Illus. $3.95.

The author of two popular books on natural history, *The Lungfish, the Dodo, and the Unicorn* and *Dragons in Amber*, has written a companion volume in the present book. The wonders of nature appear to be just as interesting as anything out of fiction. In my opinion, no writer has excelled Ley in describing both real and mythical things in nature, using a scholarly background in such a manner that the reader learns while enjoying the broad knowledge of the author.

This book goes into man's early contacts and misconceptions regarding unusual animals and plants. The discussion of each topic takes the literary detective viewpoint of the subject and then weaves natural history, past and present ideas, and controversies into a fascinating story.

The book is conveniently divided into three general sections. The first one, "Problems of the past," describes some scientific mysteries and how nature contributed to them. The chapter on cave salamanders includes a complete development of the famous Paul Kammerer controversy on the inheritance of acquired characteristics which turned out to be acquired in a manner quite independent of evolutionary changes. Legends regarding little people are found in many countries. How did these stories get started and can the mystery be solved? Ley gives an excellent account of this problem and then follows it with a good discourse on animals other than man that approach a tool-using phase of existence. Chimpanzees come closest to man on this score and exhibit abstract reasoning at times. The Abominable Snowman legends are examined and their basis critically evaluated. The development of flight and the controversies regarding both modern and extinct archetypes have a place in natural history with which few are familiar.

The second section is "Botanical interlude: three fabulous trees." The fictional and famed poison tree, usually the Upas, the fictional man-eating tree of Madagascar, and the real, practically fabulous *coco-de-mer* tree yield stories that make the scientific investigator wonder what separates fact from fiction. Nature can be so extreme that tall tales can be differentiated from fact only by tracing down reports and actual objects to their origin, either fictional or real.

The third section, "Survivors," deals with animals that almost became extinct and even were thought to be so at one time. Two birds, the cahow of Bermuda and the waldrapp of Switzerland, the sea otter, and the giant sea tortoise all exhibit survival traits that man at his worst has failed to overcome.

The bare bones discussed here cannot begin to describe the rich literary environment of the cases treated in Ley's book. Mystery, legend, and fact are blended together in a romantic form that makes this book equal to the companion volumes. The make-up is good, and I look forward to more of the same kind of thing in spite of a hint in the introduction that this may be the projected number that the author set out to write.

THOMAS S. GARDNER

Hoffman-La Roche, Inc.

Anxiety and Stress. An interdisciplinary study of a life situation. Harold Basowitz, Harold Persky, Sheldon J. Korchin, and Roy R. Grinker. Blakiston Div., McGraw-Hill, New York–London, 1955. xv + 320 pp. Illus. $8.

The principal object of this book is to present a completely coordinated multidiscipline study of anxiety. The psychosomatic and psychiatric processes involved in this emotion have been examined on a group of healthy young American men under the stress of a real-life situation—paratroop training.

The authors of this volume are well qualified to undertake teamwork of this kind, since one of them is a psychiatrist, two are psychologists, and one a biochemist. All four authors have had considerable experience in their respective fields. As they point out in their summary, the principal gain from their work has been "less in increasing our knowledge of the details of psychosomatic problems and more in learning the complexities of psychosomatic organization and integration."

The book is written in a very readable style, and we can readily follow the authors' invitation "to share with us the excitement and disappointments of participating in this—we hope novel—experience in a life situation, from the formulation of the problem to the implications of the results."

It should perhaps be pointed out, however, that stress is defined as a "threat to the fulfillment of basic needs" and is dealt with primarily at a psychological level, although cursory reference is made also to the general-adaptation syndrome and the pituitary-adrenal axis in relation to nonspecific stressor effects.

The book can be highly recommended to those interested in psychosomatic problems.

HANS SELYE

Université de Montreal

Books Reviewed in SCIENCE

13 January

Mesons and Fields, vol. II, *Mesons,* H. A. Bethe and F. de Hoffmann (Row, Peterson). Reviewed by M. L. Goldberger.

Astronomical Cuneiform Texts, vol. I, *Introduction: The Moon;* vol. II, *The Planets;* vol. III, *Plates,* O. Neugebauer, Ed. (Lund Humphries). Reviewed by I. B. Cohen.

The Chemistry and Fertility of Sea Waters, H. W. Harvey (Cambridge Univ. Press). Reviewed by E. D. Goldberg.

Diffusion and Heat Exchange in Chemical Kinetics, D. A. Frank-Kamentskii (Princeton Univ. Press). Reviewed by G. B. Kistiakowsky.

Grundlagen der Analytischen Chemie und der Chemie in Wässrigen Systemen, F. Steel (Chemie GMBH). Reviewed by T. Moeller.

20 January

Legal Medicine. Pathology and Toxicology, T. A. Gonzales *et al.* (Appleton-Century-Crofts). Reviewed by L. H. Warren.

Photosynthesis, R. Hill and C. P. Whittingham, (Methuen; Wiley). Reviewed by R. Livingston.

Kinships of Animals and Man, A. H. Morgan (McGraw-Hill). Reviewed by M. Bates.

Krebiozen; the Great Cancer Mystery, G. D. Stoddard (Beacon). Reviewed by S. Bayne-Jones.

Forestry and Related Research in North America, F. H. Kaufert and W. H. Cummings (Society of American Foresters). Reviewed by L. W. R. Jackson.

The History of the Telescope, H. C. King (Sky; Griffin). Reviewed by F. E. Edmondson.

Problems and Control of Air Pollution, F. S. Mallette, Ed. (Reinhold; Chapman & Hall). Reviewed by W. T. Sproull.

Chemistry and Chemical Technology of Cotton, K. Ward, Jr., Ed. (Interscience). Reviewed by S. J. Kennedy.

Petrographic Mineralogy, E. E. Wahlstrom (Wiley; Chapman & Hall). Reviewed by E. W. Heinrich.

Chemotherapy of Malaria, G. Covell *et al.* (WHO). Reviewed by B. B. Brodie.

27 January

The Unleashing of Evolutionary Thought, O. Riddle (Vantage Press). Reviewed by A. J. Carlson.

The Nucleic Acids: Chemistry and Biology, vol. II, E. Chargaff and J. N. Davidson, Eds. (Academic Press). Reviewed by J. F. Scott.

Principles of Animal Virology, F. M. Burnet (Academic Press). Reviewed by H. A. Howe.

Stuttering in Children and Adults, W. Johnson, Ed. (Univ. of Minnesota Press). Reviewed by B. Bryngelson.

Origins of Resistance to Toxic Agents, R. D. Reid and O. E. Reynolds, Eds. (Academic Press). Reviewed by M. H. Adams.

Index XIII to the Literature of American Economic Entomology, 1953, compiled by I. L. Hawes (Entomological Society of America). Reviewed by J. S. Wade.

The Metallurgy of Zirconium, B. Lustman and F. Kerze, Jr., Eds. (McGraw-Hill). Reviewed by S. F. Urban.

New Books

Guide to the Stars. Hector MacPherson. Philosophical Library, New York, new rev. ed., 1955. 144 pp. $2.75.

The Wing-Venation of the Orthoptera Saltatoria with Notes on Dictyopteran Wing-Venation. D. R. Ragge. British Museum (Natural History), London, 1955. 159 pp. £2.

Die Überfunktion der Nebennieren. Rudolf Chwalla. Wilhelm Maudrich, Vienna, 1955. 330 pp. $12.

Praktische Mikroskopie. Ewald Schild. Wilhelm Maudrich, Vienna, 1955. xii + 242 pp. $6.

Clinical Analgetics. E. G. Gross and M. J. Schiffrin. Thomas, Springfield, Ill., 1955. 101 pp. $3.

The Biochemistry of Semen. T. Mann. Methuen, London; Wiley, New York, 1954. 240 pp. $2.90.

Monograph of the Tenebrionidae of Southern Africa. vol. I. *Tentyriinae, Molurini—Trachynotina*: Somaticus *Hope*. Transvaal Museum Memoir No. 7. C. Koch. Transvaal Museum, Pretoria, South Africa, 1955. 242 pp.

Organic Syntheses. vol. 35. An annual publication of satisfactory methods for the preparation of organic chemicals. T. L. Cairnes, Ed. Wiley, New York; Chapman & Hall, London, 1955. 122 pp.

Crop Protection. G. J. Rose. Philosophical Library, New York, 1955. 223 pp. $10.

Virginia at Mid-Century. Jean Gottmann. Holt, New York, 1955. 584 pp. $7.50.

The Modern Building Encyclopaedia. An authoritative reference to all aspects of the building and allied trades. N. W. Kay, Ed. Philosophical Library, New York, 1955. 768 pp.

De Natura Fossilium (Textbook of Mineralogy). Special Paper 63. Georgius Agricola. Trans. from the first Latin edition by Mark Chance Bandy and Jean A. Bandy for the Mineralogical Soc. of America. Geological Soc. of America, New York 27, 1955. 240 pp.

Topsoil and Civilization. Tom Dale and Vernon Gill Carter. Univ. of Oklahoma Press, Norman, 1955. 270 pp. $3.95.

Acculturation. Critical abstracts, North America. Stanford Anthropological Ser. No. 2. Bernard J. Siegel, Ed. Stanford Univ. Press, Stanford, Calif.; Geoffrey Cumberlege, Oxford Univ. Press, London, 1955. 231 pp. $4.

The ISCC-NBS Method of Designating Colors and a Dictionary of Color Names. NBS Circular 553. National Bureau of Standards, Washington 25, 1955 (Order from Supt. of Documents, GPO, Washington 25). 158 pp. $2.

Aeroelasticity. Raymond L. Bisplinghoff, Holt Ashley, and Robert L. Halfman. Addison-Wesley, Cambridge, Mass. 1955. 860 pp. $14.50.

Learning Across Cultures. A study of Germans visiting America. Jeanne Watson and Ronald Lippit. Inst. for Social Research, Univ. of Michigan, Ann Arbor, 1955. 205 pp. $3.

A Solomon Island Society. Kinship and leadership among the Siuai of Bougainville. Douglass L. Oliver. Harvard University Press, Cambridge, Mass. 1955. 533 pp. $10.

The Coast Salish of British Columbia. Homer G. Barnett. Univ. of Oregon, Eugene, 1955. 320 pp. $5.

Vector Analysis. Homer E. Newell, Jr. McGraw-Hill, New York, 1955. 216 pp. $5.50.

Functional Analysis. Frigyes Riesz and Bela Sz.-Nagy. Trans. from French ed. 2 by Leo F. Boron. Ungar, New York, 1955. 468 pp. $10.

The Geometry of Geodesics. Herbert Busemann. Academic Press, New York, 1955. 422 pp. $9.

Eléménts de Mécanique Quantique. Ph. Pluvinage. Masson, Paris, 1955. 547 pp. Broche, F. 4000; cartonne tiole, F. 4600.

Actions Chimiques et Biologiques des Radiations. M. Haissinsky, Ed. pt. 1. *Aspects Physiques de la Radiobiologie*; L. H. Gray. pt. 2, *Chimie des Radiations des Solutions Aqueuses. Aspects Actuels des Resultats Experimentaux*; M. Le Fort. pt. 3, *Modern Trends in Radiation-Biochemistry*; W. M. Dale. Masson, Paris, 1955. 254 pp. F. 2800.

A Century of Progress in the Natural Sciences, 1853–1953. Published in celebration of the centennial of the California Academy of Sciences. California Acad. of Sciences, San Francisco, 1955. 807 pp.

Biochemistry and the Central Nervous System. Henry McIlwain. Little, Brown, Boston, 1955. 272 pp. $9.50.

An Introduction to Reactor Physics. D. J. Littler and J. F. Raffle. McGraw-Hill, New York; Pergamon, London, 1955. 196 pp. $4.50.

Handbook of Tropical Aquarium Fishes. Herbert R. Axelrod and Leonard P. Schultz. McGraw-Hill, New York, 1955. 719 pp. $10.

The Illustrated Reference on Cacti and Other Succulents. Edgar Lamb. Pitman, New York, 1955. 311 pp. $10.

How to Make Cacti Flower. E. Lamb. Pitman, New York, 1955. 80 pp. $1.95.

Family and Fertility in Puerto Rico. A study of the lower income group. J. Mayone Stycos. Columbia Univ. Press, New York, 1955. 332 pp. $6.

Control of Nuclear Reactors and Power Plants. M. A. Schultz. McGraw-Hill, New York, 1955. 313 pp. $7.50.

Dictionary of Early English. Joseph T. Shipley. Philosophical Library, New York, 1955. 753 pp. $10.

The Dispensatory of the United States of America. Arthur Osol and George E. Farrar, Jr. Lippincott, Philadelphia, ed. 25, 1955. 2139 pp. $25.

The Principles of Chemical Equilibrium. With applications in chemistry and chemical engineering. Kenneth Denbigh. Cambridge Univ. Press, New York, 1955. 491 pp. $7.50.

On the Wings of the Wind. David C. Holmes and Marvin Pitkin. McBride, New York, 1955. 204 pp. $3.50.

Final Contributions to the Problems and Methods of Psychoanalysis. vol III of *Selected Papers of Sandor Ferenczi*. Michael Balint, Ed. Trans. by Eric Mosbacher *et al.* Basic Books, New York, 1955. 447 pp. $6.50.

Growing Nuts in the North. Carl Weschcke. Webb, St. Paul, Minn., 1953. 124 pp.

Inorganic Qualitative Analysis. Semi-micro technique with estimation of concentrations. Harold A. Fales and Frederic Kenny. Appleton-Century-Crofts, New York, ed. 3, 1955. 284 pp. $3.50.

International Encyclopedia of United Science. vol. 1, pts. 1 and 2. 10 numbers of vol. I of the *International Encyclopedia of Unified Science* in two volumes. Otto Neurath, Rudolf Carnap, and Charles Morris, Eds. Univ. of Chicago Press, Chicago, 1955. 760 pp. $6. each; 2 vols., $11.

ASSOCIATION AFFAIRS

AAAS CONSTITUTION AND BYLAWS

CONSTITUTION

Article I. Purpose

Section 1. The American Association for the Advancement of Science was incorporated by an act of the General Court of the Commonwealth of Massachusetts in 1874. The Association is a nonprofit scientific and educational body.

Section 2. The objects of the American Association for the Advancement of Science are to further the work of scientists, to facilitate cooperation among them, to improve the effectiveness of science in the promotion of human welfare, and to increase public understanding and appreciation of the importance and promise of the methods of science in human progress.

Article II. Membership

Section 1. The membership of the Association shall consist of Members and Fellows. Individuals in either of these groups may become life members, emeritus members, and sustaining members in accordance with the provisions of Section 5 of this Article and with such relevant rules as the Board of Directors shall have prescribed.

Section 2. Members. Any person, institution, or organization may be admitted to the grade of Member. Each Member shall have such rights and privileges and shall pay such annual dues and fees as the Council shall have prescribed.

Section 3. Fellows. Any individual member who shall have made a meritorious contribution to science may become a Fellow of the Association under such procedures as the Board of Directors shall have prescribed.

Section 4. (*a*) *Life Members.* Any person making the Association a life-membership contribution of such amount as the Board of Directors shall have prescribed may be admitted to life membership. Each Life Member shall be exempt from the payment of annual dues and shall have all the privileges of an annual member throughout his life.

(*b*) *Emeritus Members.* Any individual annual member (a member other than a life member or a sustaining member) may be admitted to emeritus membership under such conditions as the Board of Directors shall have prescribed. Each Emeritus Member shall be exempt from the payment of annual dues and shall have all the privileges of an annual member throughout his life.

(*c*) *Sustaining Members.* Any person, institution or organization making to the Trust Funds of the Association a sustaining membership contribution of such amount as the Board of Directors shall have prescribed shall be the founder of a Sustaining Membership which shall bear a suitable name, and the fund for which shall be maintained in perpetuity as a trust. Each incumbent of a sustaining membership shall have all the privileges of a life member. The first incumbent of a sustaining membership may be either the founder himself, if an individual, or a person named by him, as the founder may choose. On the death or resignation of an incumbent, the Board of Directors may name another person to hold the membership throughout life.

Article III. Officers

Section 1. The officers of the Association shall be (a) general officers elected from among the Fellows by ballot of the Council, and (b) administrative officers elected by the Board of Directors as prescribed in Section 3 of this Article.

Section 2. General Officers. The general officers of the Association shall be the elected members of the Board of Directors, a president-elect, a president, a retiring president, and a vice president for each section. The term of office of the president-elect and of the vice presidents shall be one year and shall begin on the January 15 following their election. At the close of the one-year term of the president-elect he shall become president, and at the close of the one-year term of the president he shall become retiring president. In the event of a vacancy in the office of the president, the president-elect shall become president. In the event of a vacancy in the office of president-elect, the Board of Directors shall make a pro tempore appointment to hold until the vacancy shall have been filled by ballot of the Council. In the event of a vacancy in the office of vice president, the Board of Directors shall fill the vacancy by appointment.

Section 3. Administrative Officers. The administrative officers shall be an executive officer and such other staff members as the Board of Directors may designate and approve, a treasurer, and a secretary for each section. The executive officer, the treasurer, and their designated assistants shall be elected by the Board of Directors. The secretaries of the sections shall be nominated from among the

Fellows by the respective section committees and elected by the Board of Directors. The terms of office of each administrative officer shall be determined by the Board of Directors. The Board of Directors shall fill vacancies in the administrative offices.

Section 4. The duties of the officers shall be customary to those of the office and as further defined in the bylaws.

Article IV. Council

Section 1. The Council shall perform duties prescribed in the constitution and bylaws and shall act as an advisory body in matters pertaining to the general policies of the Association.

Section 2. The Council shall consist of (*a*) the president-elect, the president, the retiring president, the vice presidents, the secretaries of the sections, the executive officer, the treasurer, and the eight (8) elected members of the Board of Directors; (*b*) one Fellow elected by each regional division of the Association; and (*c*) the representatives of affiliated organizations as provided in Article VIII of this constitution. Each Council member shall serve until his successor shall have taken office. Each Council member shall have one vote. The president shall be chairman of the Council; if the president is unable to serve as chairman at any session, the president-elect shall serve in his stead; if neither is able to serve, the Council members in attendance shall elect a chairman for that session. Thirty (30) members of the Council shall constitute a quorum for the transaction of business.

Section 3. The Council shall meet during the annual meeting of the Association and at other times on the call of the president or upon the written request of thirty (30) members of the Council addressed to the executive officer.

Article V. Board of Directors

Section 1. The Board of Directors is the legal representative of the Association and as such shall have, hold, and administer all the property, funds, and affairs of the Association.

Section 2. The Board of Directors shall consist of eleven (11) voting members, as follows: the president-elect, the president, the retiring president and eight (8) Fellows elected by the Council, two each year, for a term of four years. The executive officer and the treasurer shall be ex officio members of the Board of Directors without vote. At any election of members of the Board of Directors not more than one Fellow serving his fourth consecutive year as an elected member may be re-elected. In the event of a vacancy in the office of an elected member of the Board of Directors, his successor for the remainder of the year shall be elected from among the Fellows by the Board of Directors and, for the remainder of the unexpired term, his successor shall be elected by the Council at the next annual election. Six (6) voting members of the Board of Directors shall constitute a quorum for the transaction of business. The retiring president of the Association shall be chairman of the Board of Directors. If he is unable to serve at any session of the Board, the Board members in attendance shall elect a chairman for that session.

Section 3. The Board of Directors shall hold four (4) meetings a year, one of which will be at the annual meeting. The Board of Directors shall also meet at the call of the chairman.

Section 4. The Board of Directors shall appoint such committees as may be necessary to aid in the management of the Association. The duties of standing committees shall be stated in the bylaws.

Section 5. The term of office of each of the eight (8) regularly elected members of the Board of Directors shall begin on January 15 following his election, and each shall serve until his successor shall have signified in writing his acceptance of election.

Article VI. Sections

Section 1. The Association shall be organized in sections in accordance with the fields of interest of its members, as determined by the Council. Each member of the Association may designate the section in which he wishes to be enrolled and may designate an additional section in which he is interested.

Section 2. The vice president for a section shall be ex officio chairman of that section.

Section 3. The affairs of each section shall be managed by a section committee consisting of (*a*) the chairman and secretary of the section; (*b*) members of the Council who represent societies affiliated with the section; and (*c*) four (4) Fellows, one elected each year by the section committee for a term of four (4) years. If an elected member of a section committee shall have resigned or died, his successor for the remainder of the unexpired term shall be elected from among the Fellows by the section committee. One-third of the members of the section committee shall constitute a quorum for the transaction of business.

Section 4. The section committee of each section shall promote the work of the Association in its own field and may organize subcommittees for that purpose. It shall arrange such section programs as it

shall deem desirable for meetings of the Association, either separately or in cooperation with other sections of the Association or with independent societies. With the approval of the Board of Directors, a section committee may arrange section meetings to be held at places and times other than those of Association meetings.

Article VII. Regional Divisions

Section 1. Regional divisions and local branches of the Association may be authorized by vote of the Council, for the purpose of promoting the work of the Association in their respective territories.

Section 2. Each regional division or local branch shall elect its officers for such terms as it shall prescribe and shall hold its meetings and conduct its affairs as it shall deem desirable, subject to the relevant provisions of this constitution and of the bylaws of the Association, and to such special provisions as the Board of Directors of the Association shall have established.

Article VIII. Affiliates and Associates

Section 1. To facilitate cooperation between the Association and other organizations, and among the latter, the Council may, on recommendation of the Board of Directors, elect an organization to be an official affiliate.

Section 2. Each organization thus designated an affiliate shall be entitled to name one Fellow of the Association to represent it on the Council; if an affiliate other than an Academy of Science has more than 100 members who are Fellows of the Association, it shall be entitled to name an additional Fellow to represent it on the Council.

Section 3. On recommendation of the Board of Directors, the Council may elect an organization to be an official associate. Associated organizations shall have the same rights and privileges as affiliated organizations except for representation on the Council.

Section 4. Organizations whose activities are planned and directed in close association with those of the American Association for the Advancement of Science may, on recommendation by the Board of Directors and approval by the Council, be designated participating organizations. Such organizations shall be represented on the Council as determined by the Board of Directors and Council.

Article IX. Meetings

Section 1. The Association shall hold an annual meeting at such time and place each year as the Board of Directors shall have determined. Other meetings of the Association or its sections may be authorized by the Board of Directors.

Article X. Publications

Section 1. The publications of the Association shall be issued in such manner as the Board of Directors may direct.

Article XI. Funds

Section 1. Funds of the Association shall be classified as Current Funds, Investment Funds, and Endowment, Trust, and Gift Funds.

(*a*) *Current Funds* shall include all dues of annual members, all receipts from publications, and all other funds received in the continuing operations of the Association.

(*b*) *Investment Funds* shall include all gifts and bequests received without special restriction concerning the use to be made of principal and income, and such other funds as may be designated by the Board of Directors as investment funds.

(*c*) *Endowment, Trust, and Gift Funds* shall consist of all life-membership contributions, all sustaining-membership contributions, all funds appropriated by the Board of Directors for establishing special life memberships, all gifts and bequests accepted with specific restrictions prohibiting their allotment to either Current Funds or Investment Funds, and such other funds as may be designated by the Board of Directors.

Section 2. The deposit, investment, and disbursement of all funds shall be subject to the direction of the Board of Directors.

Article XII. Procedure

Section 1. Roberts' rules of order, except when inconsistent with the Constitution and Bylaws of the Association, shall govern the meetings of the Council.

Article XIII. Amendments

Section 1. Amendments to this constitution may be proposed by the Board of Directors, by the Council, or by petition signed by thirty (30) members of the Council. Proposed amendments shall be published officially in substance at least one month prior to an annual meeting of the Association. A proposed amendment that is approved by the Board of Directors shall require for its adoption a favorable vote of two-thirds of the Council members present in a Council session of that meeting. A proposed amendment that is not approved

by the Board of Directors may, by majority vote of the Council members present in a Council session of that meeting, be placed on the agenda for a session of the Council at a subsequent annual meeting, and shall require for its adoption a favorable vote of two-thirds of the Council members present in a Council session of such subsequent annual meeting. Ratified amendments shall be effective upon adoption and shall be published promptly.

BYLAWS

Article I. Purpose

Section 1. The objects of the Association shall be accomplished by conducting meetings and conferences of those interested in science, its various branches, and education, producing and distributing publications, administering gifts and bequests as prescribed by the donors thereof, supporting research, making awards to recognize accomplishments in science, assisting affiliated and associated organizations, cooperating with other organizations in the advancement of science, and engaging in such other activities as shall have been authorized by the Board of Directors.

Article II. Membership

Section 1. Members who have paid dues for fifty years may be excused from further payments and still retain all the privileges of membership.

Section 2. Members may be elected by the Board of Directors to be Fellows of the Association and Fellows so elected shall remain Fellows only so long as they retain membership. If a Fellow discontinues his membership and subsequently rejoins the Association, he shall automatically again become a Fellow from the time of rejoining, without another election. Members are eligible to nomination for fellowship if they have contributed to the advancement of science either by the publication of original research or in other significant manner. Nominations for election to fellowship may be made by any three Fellows or by the executive officer or by the section committee in whose field the nominee's scientific work mainly lies.

Section 3. A Member may be dropped from membership for conduct which in any way tends to injure the Association or to affect adversely its reputation or which is contrary to, or destructive of, its objects. Charges of injurious conduct shall not be entertained against a Member unless the precise nature of the charges be submitted in writing to the president of the Association by not fewer than two Members. Upon receipt of such charges, the president shall refer them to the Executive Committee, which shall have the power to determine whether the charges shall be dropped, whether the accused shall be given an opportunity to resign, or whether the charges shall be referred to the Board of Directors for review and for final disposition. Whenever charges are referred to the Board of Directors, no person shall be dropped from membership except after opportunity to examine the evidence and to be heard and then only by a three-fourths vote of those members of the Board of Directors present and voting at a regular or special meeting.

Article III. Officers

Section 1. The executive officer shall serve as secretary to the Council and to the Board of Directors; he shall be in charge of the Association's offices and shall manage the affairs of the Association in accordance with procedures determined by the Board of Directors. He shall be an ex officio member of all standing committees.

Section 2. The treasurer shall perform the usual duties and those assigned in the bylaws.

Section 3. Reports of the executive officer and the treasurer shall be made in the manner prescribed by the Board of Directors.

Article IV

(There is no Article IV in the Bylaws, but the number is inserted here in order to preserve the parallelism between Articles in the Constitution and corresponding Articles in the Bylaws.)

Article V. Committees

Section 1. The committees shall be standing, as provided in the bylaws, or special, as the Board of Directors approves. All standing committees shall report annually in writing to the Board of Directors. The chairmen of committees shall be designated by the Board of Directors.

Section 2. During the interim between meetings of the Board of Directors, an Executive Committee consisting of the retiring president, the president, three other members of the Board of Directors elected by the Board of Directors, and the executive officer, ex officio, shall act on behalf of the Board of Directors. All actions taken by the Executive Committee shall be submitted for review and action at the next following meeting of the Board of Directors.

Section 3. The Investment and Finance Committee shall advise the Board of Directors regarding

purchases and sales of securities for the Association, shall make recommendations to the Board of Directors on financial questions, and shall have the authority to buy or sell securities under such limitations as the Board of Directors may set. The Investment and Finance Committee shall consist of the treasurer, the executive officer, and five (5) members appointed by the Board of Directors. Each appointed member shall serve a term of five (5) years, the term of one member to expire on January 14 of each year. Each shall serve until his successor shall have signified in writing his acceptance of election.

Section 4. The Committee on Affiliation and Association shall review applications for affiliation or association with the Association and make recommendations thereon to the Board of Directors. The committee shall consist of five (5) members appointed by the Board of Directors. Each member shall serve a term of five (5) years, the term of one member to expire on January 14 of each year. Each shall serve until his successor shall have signified in writing his acceptance of election.

Section 5. The Publications Committee shall give continuing scrutiny to the publications of the Association and the policies pertaining thereto and shall make recommendations thereon to the Board of Directors. The committee shall consist of five (5) members appointed by the Board of Directors. Each member shall serve a term of five (5) years, the term of one member to expire on January 14 of each year. Each shall serve until his successor shall have signified in writing his acceptance of election.

Article VI

(There is no Article VI in the Bylaws, but the number is inserted here in order to preserve the parallelism between Articles in the Constitution and corresponding Articles in the Bylaws.)

Article VII. Regional Divisions

Section 1. Regional divisions authorized by the Council have full control of their meetings, of their affiliations with other scientific organizations, and of their own activities to promote the advancement of science in their respective territories.

Section 2. The Pacific Division (organized in 1915) includes members of the Association resident in British Columbia, Washington, Oregon, California, Idaho, Nevada, Utah, Montana west of the Continental Divide, and the Hawaiian Islands.

Section 3. The Southwestern and Rocky Mountain Division (organized in 1920) includes members of the Association resident in Arizona, New Mexico, Colorado, Wyoming, Montana east of the Continental Divide, Sonora, Chihuahua, and Texas west of the 100th meridian.

Section 4. The Alaska Division (organized in 1951) includes members of the Association resident in Alaska and others who meet such requirements as may be established by the Division and approved by the Board of Directors.

Section 5. Each division shall receive for its expenses an annual allowance not to exceed one dollar for each of its members who is an Association member in good standing, or three hundred dollars ($300), whichever is larger, and shall make an annual report to the Board of Directors covering its activities and its financial situation.

Article VIII. Affiliates and Associates

Section 1. The names of affiliated and associated organizations shall be published from time to time as directed by the Board of Directors.

Section 2. Affiliated academies of science shall receive for research an annual allowance of fifty cents for each of their members who is also a member in good standing of the Association. The minimum annual allowance shall be fifty dollars. If any academy fails to utilize the research funds made available to it in any one year, these funds shall revert to the Association's treasury on December 31 of the second calendar year following the year in which the allowance was computed.

Article IX. Meetings

Section 1. The programs and arangements for the Association meetings shall be under the general direction of the Board of Directors.

Article X. Publications

Section 1. The publications of the Association shall be (*a*) SCIENCE, (*b*) THE SCIENTIFIC MONTHLY, (*c*) *Proceedings*, and (*d*) such other special publications as the Board of Directors may direct.

Section 2. The Association shall not be responsible for statements or opinions advanced in papers or in discussions at meetings of the Association or its sections, divisions, or branches, or printed in its publications, nor for statements by any of its general or administrative officers except those authorized by the Board of Directors or reflecting the duly established policies of the Association.

Article XI. Funds

Section 1. All funds shall be paid into the business office of the executive officer, where they shall

be entered in the books of the Association, and deposited in a bank designated by the Board of Directors. The treasurer shall be the custodian of all Investment Funds, Endowment, Trust, and Gift Funds, and such other funds as may be placed in his charge by the Board of Directors. The executive officer shall be the custodian of the current funds.

Section 2. All bills against members and others shall be made and collected by the business office of the executive officer.

Section 3. All expenditures shall be made in accordance with the budget of appropriations as adopted by the Board of Directors.

Section 4. All payments shall be made by the business office upon competent certification as to their correctness and proper authorization.

Section 5. Checks against the accounts of the Association will bear two signatures, from a list of individuals determined by the Board of Directors.

Section 6. The securities of the Association may be bought, sold, or exchanged only upon the written order of two of the following: the chairman of the Investment and Finance Committee, the vice-chairman of the Investment and Finance Committee, the treasurer, and the executive officer.

Section 7. The business office of the executive officer shall keep proper accounts of all financial transactions of the Association.

Section 8. The accounts of the Association shall be audited and approved annually by a certified public accountant selected by the Board of Directors.

Section 9. The executive officer shall have the authority to enter into contracts for the Association, but contract authorizations must be within the budget authorizations made by the Board of Directors.

Section 10. The policies of a participating organization may be reviewed at any time, with official representation of the participating organization present, by the Board of Directors which may make recommendations to the participating organization.

Article XII

(There is no Article XII in the Bylaws, but the number is inserted here in order to preserve the parallelism between Articles in the Constitution and corresponding Articles in the Bylaws.)

Article XIII. Amendments

Section 1. The bylaws may be amended by majority vote of the Board of Directors, provided notification of the proposed amendment has been mailed to each member of the Board at least twenty (20) days prior to the meeting.

The Constitution and Bylaws of the American Association for the Advancement of Science are being published at this time because of the numerous changes that were made by the Council at its meeting on 27 December 1955.

AAAS COUNCIL MEETING, 1955

The Council of the American Association for the Advancement of Science held its 1955 meeting in two sessions, at 4 P.M. on 27 Dec. and at 9 A.M. on 30 Dec. Both sessions were held in the Hotel Dinkler Plaza in Atlanta, Ga., and both were presided over by President George W. Beadle. Attendance at the first session was 96, and at the second session, 86.

Elections and Officers

The Council elected Laurence H. Snyder as president elect, and Paul M. Gross and George R. Harrison as members of the Board of Directors. Also elected were the vice presidents and chairmen of sections, whose names are included in the complete list of officers given on pages 155–156. Council voted to authorize the Board of Directors to elect vice presidents for those sections that had not submitted nominations at the time of the Council meeting.

Constitution and Bylaws

At its 1953 meeting, Council decided that a review of the Association's constitution and bylaws was desirable and authorized the appointment of a committee to prepare desirable changes. The committee, under the chairmanship of Wallace Brode, made an interim report at the 1954 meeting. Its final report was published, in substance, in *Science* (25 November 1955) and in *The Scientific Monthly* (December 1955). The changes recommended by the committee and endorsed by the Board of Directors were approved by Council and are incorporated in the revised constitution and bylaws that appear on pages 146–151.

Resolutions

The Council committee on resolutions (Harold H. Plough, chairman, and Detlev W. Bronk, Jane M. Oppenheimer, and Bruce D. Reynolds) considered a number of resolutions that had been submitted by several individuals and associations. Most attention, both by the committee and in the Council meeting, was given to a resolution concerning the conditions under which meetings of the Association might properly be held.

President and president elect of the AAAS: (left) Paul B. Sears, Yale University; (right) Laurence H. Snyder, University of Oklahoma.

In the several months prior to the Atlanta meeting the Association received a number of statements of objection to the holding of a meeting under circumstances that did not permit unsegregated housing, eating, and transportation accommodations for all members. These conditions were not, and under existing laws could not be, met in Atlanta. This fact had been known to the Board of Directors when the decision to hold a meeting in Atlanta was reached in 1953 and was known by Council when the Atlanta meeting was discussed at the 1953 meeting.

The Board of Directors believed that in spite of the difficulties presented by enforced segregation, a meeting in Atlanta was nevertheless desirable because of the advantages of bringing a meeting to a region of the country that has shown marked scientific, technological, and educational growth since the last visit of the AAAS, and of thus making it easier for the scientists, regardless of color, of that region to attend than would be possible if all meetings were held in other parts of the country. Moreover, the meeting itself was unsegregated, and in the minds of some of the participants the holding of a conspicuously unsegregated meeting was itself a positive contribution toward the breakdown of segregation practices. In this climate of differing points of view, the Committee on Resolutions considered the various resolutions that had been submitted and prepared for Council's consideration the following resolution.

"The American Association for the Advancement of Science is a democratic association of all its members; no one is barred from election because of race or creed. All members are privileged to cooperate freely in the fulfillment of the Association's high objectives which are the furtherance of science and human welfare. No member is limited in his service because of race or creed.

"In order that the Association may attain its objectives, it is necessary and desirable that all members may freely meet for scientific discussions, the exchange of ideas, and the diffusion of established knowledge. This they must be able to do in formal meetings and in informal social gatherings. These objectives cannot be fulfilled if free association of the members is hindered by unnatural barriers.

"Therefore be it resolved that the annual meeting of the American Association for the Advancement of Science be held under conditions that make possible the satisfaction of those ideals and requirements."

After extensive debate over the effects and propriety of adopting such a resolution, and following the defeat of motions to table the resolution and to make it an order of business at the 1956 meeting, Council voted to submit the resolution by mail to the entire Council membership. It was further voted that following the receipt of ballots on the resolution, the AAAS office should publish the resolution and the vote on it.

It can now be reported that the resolution was adopted by a mail vote of 224 to 31, with 3 abstaining, and that the resolution and the fact of its adoption were on 23 January 1956 released to the press.

As a second resolution, the committee recommended adoption of the following:

"BE IT RESOLVED that the American Association for the Advancement of Science endorses the efforts being made to amend the McCarran-Walter Act to remove those provisions that limit the travel of recognized foreign scholars and scientists to this country, for limitation on the free interchange of knowledge constitutes a serious impediment to scientific progress."

Council voted to adopt this resolution.

As a third resolution, the committee recommended adoption of the following:

"BE IT RESOLVED that the American Association for the Advancement of Science favors the use of funds of the United States through the National Science Foundation and other appropriate government agencies to supplement the travel costs of U.S. citizens to attend scientific meetings and congresses in foreign countries on the ground that the interchange of information resulting greatly strengthens our own scientific competence."

Council voted to adopt this resolution.

As a fourth resolution, the committee recommended the following:

"BE IT FURTHER RESOLVED that the American Association for the Advancement of Science wishes to express its appreciation and thanks to the local committee and all other individuals and organizations who have cooperated to make our 1955 meetings pleasant and profitable. We will take back to our homes an enhanced regard for the hospitality and an increased respect for the scientific and educational institutions in and around Atlanta."

Council voted to adopt this resolution.

Finally, the committee reported that it had considered several other resolutions but that it had decided not to recommend any of them for adoption. From the floor it was moved that Council adopt the following resolution that calls for the creation of an interim committee on the social aspects of science.

"Whereas science has become one of the major factors of modern civilization; and whereas its rapid development has and is producing many major sociological problems affecting the efficiency of research, the application of the results of research, the incorporation of its concepts and its results into the social structure, and the actual conduct of research and the development of science; and whereas it is highly likely that the welfare of science and of society will be promoted by a comprehensive examination of the problems being created; and whereas the American Association for the Advancement of Science is representative of the broad scope of science and has already assumed some responsibility for the broad problems created by science; it is hereby resolved that the Council of the American Association for the Advancement of Science should organize an interim committee to be called 'The Interim Committee on the Social Aspects of Science.' It is recommended that this committee shall be composed of five members of the Council and be appointed by the president of the AAAS for a period of 1 year. The committee shall examine generally the sociological problems being created by science and present to the next annual meeting of the Council recommendations for action if such are found necessary."

Council voted to adopt this resolution and instructed the president to appoint the committee.

At the conclusion of the report of the Committee on Resolutions, Council voted a resolution of thanks to the committee for its excellent work.

Election Procedure

At the 1954 Council meeting there was considerable discussion of the shortcomings of the existing method of conducting Association elections for the offices of president elect and member of the Board of Directors. At that meeting, the Committee on Constitution, Bylaws, and General Operations was requested to bring to the 1955 meeting recommendations for an altered election system. The committee recommended establishment of a nominating committee to consist of two members of the Board of Directors, the senior member to serve as chairman, and five members of Council. Terms are for 2 years and are to be staggered so that the terms of at least three members, including one from the Board of Directors, will expire each year. The nominating committee will use such means as it decides upon—but it was recommended that the policy of sending a nominating ballot to all members of Council be continued—to select a slate of two or more nominees for each position for which an election is to be held. The names of the nominees will be published in time to permit the addition of other names by petition signed by 30 or more members of Council. Election will then be conducted by mail ballot, with a preferential ballot being used in case there are more than two persons nominated for an office. Results of the election will be announced at the following meeting of Council and/or will be published.

AAAS Operating Fund Budget, 1956

Item	Receipts
Dues of annual members	$310,000
Journal subscriptions (treasurer)	3,530
Members' special subscriptions	
Science	2,800
The Scientific Monthly	16,500
Nonmember subscriptions	
Science	43,000
The Scientific Monthly	20,000
Miscellaneous sales	
Science	1,600
The Scientific Monthly	1,600
Advertising	
Science	200,000
The Scientific Monthly	15,000
Sale of:	
Microcards	450
Binders	1,600
Symposium volumes	21,000
Emblems	1,600
Other sales	600
Meeting	
Registrations, program sales	5,500
Program advertising	2,000
Contributions	6,000
Exposition	
Booth space	14,000
Science library	1,500
Rental receipts	8,000
Income from investments	9,500
Cash discounts	200
Other receipts	300
High-school science libraries	1,000
STIP	9,000
Total receipts	$696,280

Item	Expenses	Authorized limits for individual items
General administrative expenses		
Salaries	$189,000	$215,000
Insurance, retirement, and social security	13,300	15,000
Building maintenance	20,500	24,000
Rent	7,000	8,000
Interest on mortgage	7,800	7,800
Supplies and equipment	20,800	25,000
Telephone and telegraph	3,000	3,800
Postage	12,500	13,500
Travel	5,500	6,500
Miscellaneous	13,800	16,000
Printing		
Science	240,000	260,000
The Scientific Monthly	60,000	65,000
Symposium volumes	15,000	20,000
Annual meeting		
Meeting and exposition	19,800	22,000
Press service	5,000	5,500
Sections, divisions, boards and committees		
Section expenses	5,000	6,000
Allowances to divisions	7,500	8,000
Board of Directors	6,500	7,400
Editorial Board and Publications Committee	8,000	9,500
Other committees	2,000	3,500
Advertising, cost of selling	39,000	42,000
Miscellaneous	1,000	2,500
Contingency and new activities	10,000	10,000
Total operating fund	$712,000	
Plus partial repayment of building loan	14,000	
	$726,000	

Within individual budget categories, expenditures up to the amounts indicated in the column headed "Authorized limits for individual items" are allowed, so long as the total expenditures do not go above the approved total amount, $712,000 (or $726,000, including $14,000 for repayment of funds borrowed for construction of the headquarters building). It should be noted that this budget applies only to the Association's operating funds and does not include funds in the treasurer's account or money to be spent on such special projects as the Science Teaching Improvement Program and the Traveling High-School Science Libraries.

Council voted to adopt this revised election procedure. It will therefore be the one used in the election during the fall of 1956. In order to get the new procedure started, it was necessary to select the members of the nominating committee. Wallace Brode, chairman of the committee that had recommended the revised procedure, served as chairman of an ad hoc committee to present a slate of names for membership on the nominating committee. He reported that the Board of Directors had selected Chauncey D. Leake for a 1-year term and Margaret Mead for a 2-year term. Upon recommendation of the committee, Council elected Barry Commoner and H. B. Sprague for 1-year terms and Marsh White, Nelson Sayer, and Milton Lee for 2-year terms.

As alternates for any of the Council members who might not be able to serve, Council elected George Paffenbarger, Jane Oppenheimer, Bentley Glass, and Murray Luck.

Affiliates and Associates

Upon recommendation of the Committee on Affiliation and Association, Council elected the following five organizations to affiliate status:

American Documentation Institute
American Institute of Chemists
American Institute of Industrial Engineers
The National Society of Professional Engineers
Poultry Science Association

and the following two organizations to associate status:

Council of American Bioanalysts
Society for Industrial and Applied Mathematics

Upon recommendation of the Academy Conference, Council voted to suspend the affiliate status of the Missouri Academy of Sciences, since this organization has become completely inactive.

Following these actions, the figures on affiliated and associated organizations became: affiliated societies, 169; affiliated academies of science, 41; associated societies, 55; total, 265.

Other Business

The Council discussed means of increasing attendance at its meetings and considered a suggestion from the Committee on Constitution, Bylaws, and General Operations that the Association might charge each of its affiliates an annual fee and use the money so obtained to help pay travel expenses of Council members. Council instructed the Board of Directors to consider this suggestion and to correspond with the affiliated societies to determine their views.

Three reports were given. Warren Weaver, chairman of the Board of Directors, reported activities and plans of the committees appointed by the National Academy of Sciences–National Research Council to study the effects of radiation. These committees were of special interest because Council had voted at the 1954 meeting to instruct Weaver to appoint a similar committee for the Association. Discussions subsequent to the 1954 meeting made it apparent that there would be considerable overlap in function and probably also in personnel between the two bodies. Upon Weaver's recommendation, Council therefore voted, by mail, to rescind its earlier instruction.

Weaver's report indicated that the intention of the decision to appoint an Association committee was being carried out, even though the Association itself did not have a committee working on radiation effects. Dael Wolfle, administrative secretary, reported on the major program activities of 1955 and the Association's financial situation. The financial balance sheet for 1955 cannot be reported until after it has been audited, but preliminary figures indicate that income and expenses for the year were approximately in balance. He reported also that gifts and grants either unrestricted or for special purposes received or committed during the year amounted to $430,000. John Mayor, director of the Science Teaching Improvement Program, reported on the activities and plans directed toward the improvement of the teaching of science and mathematics at the high-school level.

The amended constitution and bylaws provide for the naming of certain organizations as "participating organizations." Such organizations are defined as ones whose programs are planned and carried out in close cooperation with the Association. They are entitled to such representation in Council as the Board of Directors and the Council may determine. Council voted to elect the Gordon Research Conferences as a participating organization—the first organization to be elected to this status—and voted also to invite the Conference to name two representatives to Council.

President Beadle announced that the budget for 1956 could not be presented to the Council meeting but would be published as part of the proceedings of the meeting. It appears on page 154.

DAEL WOLFLE

Executive Officer

AAAS OFFICERS, COMMITTEES, AND REPRESENTATIVES FOR 1956

Following are the officers, committee members, and representatives of the American Association for the Advancement of Science. (Dates in parentheses indicate year of expiration of term.)

President: Paul B. Sears (1957), Yale University

President Elect: Laurence H. Snyder (1958), University of Oklahoma

Retiring President and Chairman of the Board of Directors: George W. Beadle (1956), California Institute of Technology

Other Members of the Board of Directors

Mark H. Ingraham (1956), University of Wisconsin

Paul E. Klopsteg (1956), Glenview, Illinois

Wallace R. Brode (1957), National Bureau of Standards

Thomas Park (1957), University of Chicago

Chauncey D. Leake (1958), Ohio State University

Margaret Mead (1958), American Museum of Natural History

Paul M. Gross (1959), Duke University

George R. Harrison (1959), Massachusetts Institute of Technology

Paul A. Scherer (ex officio), Carnegie Institution of Washington

Dael Wolfle (ex officio), AAAS

Vice Presidents and Chairmen of the Sections

A Mathematics: D. H. Lehmer, University of California, Berkeley

B Physics: William F. Meggers, National Bureau of Standards

C Chemistry: Karl Folkers, Merck and Company

D Astronomy: Peter van de Kamp, Swarthmore College

E Geology and Geography: not yet appointed

F Zoological Sciences: Bentley Glass, Johns Hopkins University

G Botanical Sciences: Paul J. Kramer, Duke University

H Anthropology: William L. Straus, Jr., Johns Hopkins University

I Psychology: Clarence H. Graham, Columbia University

K Social and Economic Sciences: Benjamin H. Williams, Industrial College of the Armed Forces

L History and Philosophy of Science: Henry Guerlac, Cornell University

M Engineering: Clarence E. Davies, American Society of Mechanical Engineers

N Medical Sciences: Irvine H. Page, Cleveland Clinic

Nd Dentistry: H. Trendley Dean, American Dental Association

Np Pharmacy: Rudolph H. Blythe, Smith, Kline and French Laboratories

O Agriculture: H. B. Sprague, Pennsylvania State University

P Industrial Science: Monroe E. Spaght, Shell Oil Company

Q Education: D. A. Worcester, University of Nebraska

Administrative Officers

Appointed by the Board of Directors

Executive Officer: Dael Wolfle

Treasurer: Paul A. Scherer

Associate Administrative Secretaries: Raymond L. Taylor and John A. Behnke

Editor: Graham DuShane

Secretaries of the Sections

A Mathematics: Rudolph E. Langer (1956), University of Wisconsin

B Physics: J. Howard McMillen (1959), National Science Foundation

C Chemistry: Edward F. Degering (1956), QM Corp, USA, Natick, Mass.

D Astronomy: Frank K. Edmondson (1957), Goethe Link Observatory, Indiana University

E Geology and Geography: Robert L. Nichols (1956), Tufts College

F Zoological Sciences: Harold H. Plough (1959), Amherst College

G Botanical Sciences: Barry Commoner (1959), Washington University, St. Louis

H Anthropology: Gabriel W. Lasker (1957), Wayne University College of Medicine

I Psychology: Conrad G. Mueller (1956), Columbia University

K Social and Economic Sciences: Donald P. Ray (1958), George Washington University

L History and Philosophy of Science: Jane M. Oppenheimer (1958), Bryn Mawr College

M Engineering: Frank D. Carvin (1956), Illinois Institute of Technology

N Medical Sciences: Allan D. Bass (1956), Vanderbilt University School of Medicine

Nd Dentistry: Russell W. Bunting (1958), University of Michigan School of Dentistry

Np Pharmacy: John E. Christian (1958), Purdue University School of Pharmacy

O Agriculture: F. D. Keim (1957), University of Nebraska

P Industrial Science: Allen T. Bonnell (1956), Drexel Institute of Technology

Q Education: Herbert A. Smith (1959), University of Kansas

Officers of the Pacific Division

President: Robert B. Brode, University of California, Berkeley

President Elect: J. Murray Luck, Stanford University

Retiring President: Edwin R. Guthrie, University of Washington

Secretary: Robert C. Miller, California Academy of Sciences

Council Representative: Robert C. Miller

Officers of the Southwestern and Rocky Mountain Division

President: E. F. Castetter, University of New Mexico

Vice President: Marlowe G. Anderson, New Mexico College of Agriculture and Mechanic Arts

Executive Secretary: Frank E. E. Germann, University of Colorado

Council Representative: Frank E. E. Germann

Officers of the Alaska Division

President: Neil W. Hosley, University of Alaska

Vice President: John Dassow, Fisheries Research Laboratory, U.S. Fish and Wildlife Service, Ketchikan

Secretary: Arthur Buswell, Extension Service, University of Alaska

Council Representative: Troy L. Péwé, U.S. Geological Survey, College

Standing Committees

Affiliation and Association

Fernandus Payne (1956), chairman, Indiana University

I. Melville Stein (1957), Leeds & Northrup Company, Philadelphia
Fredrick J. Stare, Jr. (1958), Harvard School of Public Health
Herbert Carter (1959), University of Illinois
Luna Leopold (1960), U.S. Geological Survey, Washington, D.C.
Dael Wolfle, ex officio
John A. Behnke, staff representative

AAAS Meetings
Harry C. Kelly (1956), chairman, National Science Foundation
Clarence E. Davies (1956), American Institute of Mechanical Engineers, New York
Arthur W. Galston (1956), Yale University
Howard M. Phillips (1958), Emory University
Dael Wolfle, ex officio
Raymond L. Taylor, staff representative

Executive
George W. Beadle, chairman
Paul B. Sears
Laurence H. Snyder
Wallace R. Brode
Paul E. Klopsteg
Dael Wolfle

Investment and Finance
Sheldon B. Akers (1956), vice chairman, Brookings Institution
F. P. H. Siddons (1957), chairman, American Security & Trust Company, Washington, D.C.
Malvern F. Morse (1958), American Security & Trust Company
Wallace R. Brode (1959)
J. E. Graf (1960), Smithsonian Institution
Paul A. Scherer, ex officio
Dael Wolfle, ex officio
Hans Nussbaum, staff representative

Publications
Paul B. Sears (1956)
Thomas Park (1957), chairman
Ralph R. Shaw (1958), Rutgers University
Chauncey D. Leake (1959)
George R. Harrison (1960)
Dael Wolfle, ex officio
Graham DuShane and John A. Behnke, staff representatives

Special Committees

AAAS-Anne Frankel Rosenthal Memorial Award for Cancer Research
Warren Weaver, chairman, Rockefeller Foundation
Jacob Furth, American Association for Cancer Research
G. Burroughs Mider, National Cancer Institute
Richard L. Rosenthal, The Richard and Hinda Rosenthal Foundation
C. Chester Stock, Sloan-Kettering Institute for Cancer Research
Harry M. Weaver, American Cancer Society

Management and Business Operations
Mark H. Ingraham, chairman
George J. Beal, Rockefeller Foundation (Retired)
F. P. H. Siddons
Paul A. Scherer, ex officio
Dael Wolfle, ex officio

Membership Development
Ralph W. Gerard, chairman, University of Michigan, Ann Arbor
Clarence E. Davies
Rensis Lickert, University of Michigan
All members of the AAAS staff as consultants

Nominations
Chauncey D. Leake (1956), chairman
Margaret Mead (1957)
Barry Commoner (1956)
H. B. Sprague (1956)
Marsh W. White (1957), Pennsylvania State University
A. Nelson Sayre (1957), U.S. Geological Survey
Milton O. Lee (1957), Federation of American Societies for Experimental Biology

Research Grants, AAAS
Barry Commoner, chairman
E. Lowell Kelley, University of Michigan
Hans Nussbaum
Laurence H. Snyder
H. Burr Steinbach, University of Minnesota
Dael Wolfle, staff representative

Retirement Plan (must be three staff members)
Dael Wolfle, chairman
Hans Nussbaum
Raymond L. Taylor

Source Books in the History of Science
Gregory D. Walcott, chairman, Long Island University
Harlow Shapley, Harvard University
Edmund W. Sinnott, Yale University
John A. Behnke, staff representative

Committees To Be Appointed

Interim Committee on the Social Aspects of Science
Newcomb Cleveland Prize, Judges
Resolutions
Socio-Psychological Prize, Judges
Theobald Smith Award in the Medical Sciences, Judges

Paul M. Gross (left) vice president and dean of Duke University, Durham, N.C., and George R. Harrison (right), professor and dean of science at Massachusetts Institute of Technology, Cambridge, are new members of the AAAS Board of Directors. Gross, who is also president of the Oak Ridge Institute of Nuclear Studies and vice chairman of the National Science Board, has done his chief scientific work in physical chemistry. Harrison has served in a civilian capacity with the U.S. Atomic Energy Commission and the Office of Scientific Research and Development. His scientific field is physics. [Harrison photo by Fabian Bachrach]

Representatives

On American Council on Education
Mark H. Ingraham
John R. Mayor, AAAS

Of Board of Directors on Cooperative Committee on the Teaching of Science and Mathematics
Harold K. Schilling, Pennsylvania State University

On Board of Trustees of Science Service
Kirtley Mather (1956), Harvard University
Paul B. Sears (1957)
Karl Lark-Horovitz (1958), Purdue University

On Council of National Organizations of the Adult Education Association of the United States
John A. Behnke

On Council of Old World Archeology
Richard K. Beardsley, University of Michigan

On Committee on the Kimber Genetics Award of the National Academy of Sciences
I. Michael Lerner, University of California, Berkeley

On National Citizens Committee for Educational Television Advisory Committee
John A. Behnke

On National Committee for UNESCO
Elvin C. Stakman, University of Minnesota, St. Paul

On National Conference on FAO
Noble Clark, University of Wisconsin, Agricultural Experiment Station

On Scientific Manpower Commission
Detlev W. Bronk, Rockefeller Institute for Medical Research (Wallace R. Brode, alternate)
Dael Wolfle

On U. S. Committee on ISO Technical Committee 37—Terminology
Duane Roller, Ramo-Wooldridge Corporation, Los Angeles

AAAS Membership

1)	*Changes during 1955*		
	New members		5,395
	Deaths	273	
	Resignations	1,068	
	Automatic resignations	2,525	3,866
	Increase during 1955		1,529
2)	*Totals as of 31 Dec. 1955*		
	Paid for 1955		32,922
	Paid through March 1956		599
	Paid through June 1956		10,976
	Paid through September 1956		1,073
	Life members, etc.		791
	In good standing		46,361
	In arrears		2,971
			49,332
	New for 1956		857
	Total membership		50,189

REPORT OF THE ATLANTA MEETING

For the more than 4000 persons who attended, the 122nd meeting of the American Association for the Advancement of Science in Atlanta, Ga., will long be remembered, not only for the high quality and timeliness of the programs and for the opportunities for scientists of different disciplines to commingle with colleagues from all parts of the continent, but also for the friendliness and helpfulness shown generally by the local citizens with whom the visitors came in contact. It was a notably pleasant meeting in a historic city, which, since the previous meeting there in 1913, has shown many developments in science, technology, public health, and education.

Between the first few events on 26 Dec.—a panel of Section Q, "Developing leaders in science"; a symposium of the American Association of Clinical Chemists; and Section F's first session for contributed papers—and the two final events of Friday evening 30 Dec.—the 16th annual address of the United Chapters of Phi Beta Kappa, "Science and the other humanities," given by Laurence M. Gould, president of Carleton College, and an open house for astronomers at Agnes Scott College's Bradley Observatory—there were some 250 sessions devoted to symposia, groups of invited papers, panel discussions, short reports of current research, addresses, lectures, business meetings, meal functions, tours, and field trips. There were programs sponsored or cosponsored by the Association as a whole, by 17 of the 18 AAAS sections, and by 68 participating societies and other organizations.

As usual, with so many sessions crowded into the principal 4 days, the substantial over-all attendance was subdivided into areas of major interests. For the first time in recent years, no secretary or program chairman wished to hold sessions on 31 Dec. Despite efforts to avoid the scheduling of concurrent sessions likely to appeal to the same potential audiences, there were several instances where this was not possible. Some outstanding programs had audiences smaller than they deserved—partly because of such conflicts and partly, probably, because of insufficient premeeting publicity by those who arranged them. The schedules of some of the participating societies were so compressed or intensive that little or no time was available for other programs except at the expense of their own sessions. At any particular session, however, each program chairman or presiding officer could be sure that his speakers were addressing an audience that had chosen his program above all others and despite such distractions as committee meetings, informal conferences, or "convention fatigue."

The events sponsored by the Association as a whole had good attendance. This was particularly true of the special program, "The crisis in science education," the time for which had been cleared by all sections and by most of the participating societies, and the AAAS presidential address, on 28 Dec., by courtesy, generally left free by the participating societies whenever possible. The papers of the education program by Charles Dollard, formerly president of Carnegie Corporation of New York; Arthur S. Flemming, director, Office of Defense Mobilization; and Alan T. Waterman, director, National Science Foundation, will be published in one of the Association's journals.

Taking all factors into account, the second Atlanta meeting was successful in its primary objectives. Among the participating societies, the annual national meeting of the American Phytopathological Society had a gratifyingly large number of its members in attendance, the American Society of Parasitologists had to open additional concurrent sessions for its 130 papers and seek larger session rooms, and the four science teaching societies were pleased with the size of their registrations. The Association appreciates the large number of AAAS registrations by the members of these and of other participating societies.

Among the 64 symposia, the following were noteworthy for their interdisciplinary scope: "Atomic energy and agriculture," sponsored jointly by the AAAS and the Oak Ridge Institute of Nuclear Studies; the three sessions of the International Geophysical Year; Section C's "Patterns of biochemical and histological responses to chemical agents"; "The species problem" of the Association of Southeastern Biologists; "Applications of serology in biological research," sponsored by the Society of General Physiologists; Section L's "Creativity in science"; "Socio-economic aspects of orthopedic engineering," arranged by Section M; Section N's "Microbiology and medical research"; and "Physiological bases in psychiatry," sponsored jointly by the American Psychiatric Association and the American Physiological Society. Most of these were two or four sessions in length and had speakers from many parts of the country.

There were also the customary features expected at AAAS meetings—outstanding evening addresses sponsored by the Society of the Sigma Xi, the Scientific Research Society of America, the National Geographic Society, and the United Chapters of Phi Beta Kappa; large-scale exhibits; the latest foreign and domestic scientific films; and the traditional "Biologists' Smoker" (for all registrants) with refreshments and cigarettes again generously contributed by the Coca-Cola Company, the Na-

tional Biscuit Company, and Phillip Morris Inc.

Planning the meeting. The decision to meet in Atlanta was made by the AAAS Board of Directors at their June meeting in 1953 after a survey of the physical facilities of the city and after a careful consideration of all advantages and disadvantages.

In common with other large national scientific organizations, the AAAS has consistently met in different sections of the United States and Canada, as physical facilities would permit, in order to make it possible, at least at intervals, for all of its members to attend the annual convention at minimum expense. The 1954 meeting in Berkeley, California, the Association's first national winter meeting on the Pacific Coast, was a recognition, long overdue, of the ever growing AAAS membership west of the Rockies. Similarly, the 1955 meeting in Atlanta was a return to the South for the first time since the Dallas meeting of 1941, and to the Southeast, since the Richmond, Va., meeting of 1938. The first AAAS meeting in a southern state was the Charleston, S.C., meeting, in 1850, when the Association was 2 years old. The enlarged Municipal Auditorium of Atlanta, the splendid new classroom building of the nearby State College of Business Administration, and additions to Atlanta's downtown hotel facilities once more made it possible to hold a meeting of substantial size in this growing metropolis of the Southeast.

In Atlanta it was possible to assign to the relatively large American Phytopathological Society the Atlanta Biltmore Hotel, best suited for that group's many concurrent sessions and other functions, and to meet the preferences of the zoological and science teaching societies for the recently enlarged Hotel Dinkler Plaza. The Municipal Auditorium, six or seven blocks from the downtown hotels, was the logical site for the center of the meeting—the Main Registration-Information Center, the Visible Directory of Registrants, the exhibits, the Science Theatre, and a snack bar open to all registrants. Most of the sectional programs were held in the session rooms of this auditorium and in the new classroom building of the State College of Business Administration, immediately across the street. It was necessary, however, to hold sessions in several other hotels, the Henry Grady, Piedmont, Georgian Terrace, and Georgia. By choice of the organizations concerned, there were a few events on such widely scattered campuses as Agnes Scott College, Atlanta University, Emory University, and Georgia Institute of Technology.

The Atlanta Biltmore and nearby Georgian Terrace and Cox-Carlton hotels, which are 1½ miles north of the downtown hotels, were well served by the trackless trolleys and buses of the Atlanta Transit Company. For additional transportation, however, these hotels were linked with the downtown hotels and with the Municipal Auditorium by shuttle buses chartered by the Association. These proved particularly convenient in carrying people to and from Atlanta University for the zoologists' and botanists' dinners and the AAAS presidential address and reception.

AAAS presidential address and reception. On the customary evening, 28 Dec., the traditional address by the retiring, 107th, president of the Association, Warren Weaver, was given in the attractive Sisters Chapel of Spelman College of Atlanta University. AAAS president George W. Beadle presided. Robert S. Lynch, president of the Atlantic Steel Company, and general vice chairman of the Atlanta committees, welcomed the Association and the sizable audience on behalf of the entire scientific and academic community. President Beadle, after a brief tribute to a distinguished scientific career, then presented the speaker of the evening whose address, "Science and people" [*Science* **122**, 1255 (1955)], emphasized that science, essentially, is not an esoteric field for human endeavor; scientists are like other people; and the fruits of their researches belong to all the people. Other members of the platform party included Paul B. Sears, who assumed office as AAAS president 15 Jan. 1956; Rufus E. Clement, president, Atlanta University; Albert E. Manley, president, Spelman College, Dael Wolfle, executive officer, and Raymond L. Taylor, associate administrative secretary.

Immediately following the address a reception was held in the adjacent gymnasium. It was a pleasant climax to a crowded day and one of the highlights of the meeting.

AAAS general symposium. Early last year the Oak Ridge Institute of Nuclear Studies accepted the Association's invitation to arrange a symposium on the same high level as its program at the AAAS meetings of 1950, 1951, and 1952. As the committee headed by Cyril Comar, principal scientist, Medical Division, ORINS, developed its plans, the four-session symposium, "Atomic energy and agriculture," evolved partly in recognition of the South's emergence as one of the great sources of food for the whole nation and partly because of the important implications of the uses of radioisotopes in the agricultural sciences. In view of the scope and stature of this program, which was coordinated with the subsequent conference at East Lansing, Mich., 12–14 Jan. 1956, its four parts—soil-plant relationships, plant metabolism and crop improvement, animal metabolism, and food sterilization—were cosponsored by the Association as a whole and by Section O. Additional cosponsors of part I were

Section G and the Ecological Society of America; of part II, Section G and the American Society of Plant Physiologists, Southern Section; and of part III, Section F. This program will appear as an AAAS symposium volume.

Other symposia. At Atlanta there were 63 other programs, classifiable as symposia, groups of invited papers, or panels that centered about particular themes. Thirty-one of these were sponsored by 14 of the 17 AAAS sections; another 32 had been arranged by 39 of the 68 participating organizations. This total exceeds the number at any previous AAAS meeting, except at Berkeley in 1954. It would be impracticable to repeat here the entire list, which has appeared both in the General Program-Directory and in the preconvention issue of *Science*, but a few that were interdisciplinary in scope have already been mentioned. Of interest is the fact that the societies arranged exactly the same number of such programs as did the Association and its sections; moreover, each group of 32 occupied 47 sessions.

Conferences. At present there are three recurrent conferences at AAAS meetings. The Academy Conference, made up of the official delegates of the 41 active academies of science affiliated with the Association and others interested in academy affairs, had a full day on 28 Dec. with a business meeting in the morning, a panel discussion on the role of the academies in the AAAS Science Teaching Improvement Program, and an address on science fairs by Clinton L. Baker in the afternoon, followed in the evening by the annual Academy Conference dinner. The Conference on Scientific Manpower dropped its plans for a separate program this year, to cosponsor the Association's special program, "The crisis in science education." On 27 Dec., the first of the seven AAAS special sessions—the annual address of the Society of the Sigma Xi, held in conjunction with its 56th convention—had dealt with manpower problems in the paper, "Is there a scarcity of scientists?" by James R. Killian, Jr., president, Massachusetts Institute of Technology. Finally, the two sessions of the AAAS Cooperative Committee on the Teaching of Science and Mathematics were concerned with specific aspects of this complex problem.

The Conference on Scientific Editorial Problems at this meeting experimented with five concurrent discussion panels preceded and followed by plenary sessions. The tentative plans for this year's New York meeting are to revert to six or more consecutive sessions for the entire attendance.

AAAS business sessions. As required by the constitution, the Association's board of directors held its fourth regular meeting of the year at the annual meeting; as usual, its sessions preceded the two sessions of the Council, which are reported elsewhere. The AAAS section officers luncheon and business meeting held at the Central YMCA was well attended. There was considerable thoughtful discussion on the perennial problem of too many excellent symposia in potential conflict with one another, which will be conveyed to the standing Committee on AAAS Meetings.

Attendance. The second Atlanta meeting was average in size for the past 10 years, which, in terms of the region in which it was held, means it was (i) larger than any other AAAS meeting in the South and (ii) larger than any other scientific meeting in the South. It was strongly supported by southern scientists and teachers. Of the 2636 paid registrants, 1956, or 59 percent, came from 15 southern states, led by Georgia with 636. Considering the still relatively low population of scientists in this geographically large region, this is a high figure indeed. It was also a great national meeting with an excellent international representation. As Table 1 shows, every state in the Union, except Idaho and Nevada, was represented and, among the 18 foreign countries represented, there were 41 delegates from Canada and five from Mexico.

For those interested in comparisons, the 1941 meeting in Dallas had 1851 paid registrants. The 1938 meeting in Richmond, which is still remembered as jamming that city, had 2553 paid registrants. In both of these years, the botanical societies, the horticulturists, the geneticists, the American Society of Zoologists, and other societies—none of whom held their 1955 meetings with the Association in Atlanta—met with the AAAS and contributed perhaps two-thirds of the attendance. Undoubtedly, as Table 2 suggests, all of these societies, however, were represented by some of their members.

The *total attendance* of professional scientists, faculty members, other teachers, and graduate students at any national meeting of the Association is always greater than the number of paid registrations, since all programs are open to everyone. At Atlanta, the percentage of AAAS registrations by members of societies maintaining separate registrations was higher than usual—but undoubtedly there were some who regarded a "double registration" as superfluous or onerous. In one sense these persons are registrants, but they are anonymous as far as the AAAS registration records are concerned and cannot be included.

The 122 representatives of the press, many of whom attended sessions at Atlanta, were issued complimentary badges and naturally are not included as paid registrants in Table 2. Similarly, several hundred exhibitor personnel, most of them

Table 1. Distribution of paid registrants by states and countries.

Alabama	86	Tennessee	125
Arizona	3	Texas	62
Arkansas	16	Utah	7
California	49	Vermont	3
Colorado	7	Virginia	62
Connecticut	32	Washington	10
Delaware	11	West Virginia	9
District of Columbia	89	Wisconsin	36
Florida	140	Wyoming	3
Georgia	636	Total, continental U.S.	2564
Illinois	81		
Indiana	42		
Iowa	26	Alaska	1
Kansas	18	Canada	41
Kentucky	22	Colombia	3
Louisiana	49	Costa Rica	2
Maine	4	Cuba	1
Maryland	141	Egypt	1
Massachusetts	52	Germany	1
Michigan	52	Guatemala	1
Minnesota	35	Holland	1
Mississippi	27	Honduras	1
Missouri	26	India	2
Montana	2	Iran	1
Nebraska	11	Japan	1
New Hampshire	4	Korea	1
New Jersey	56	Mexico	5
New Mexico	8	New Zealand	1
New York	180	Philippines	1
North Carolina	98	Portugal	1
North Dakota	1	Puerto Rico	5
Ohio	79	Thailand	1
Oklahoma	24	Total, territorial and foreign	72
Oregon	1		
Pennsylvania	81	Total paid registrations	2636
Rhode Island	6		
South Carolina	51		
South Dakota	1		

with individual scientific interests, were issued complimentary badges, but these too are not included. With the attendance at the annual illustrated lecture of the National Geographic Society considered, in addition to the figures shown in Table 2, the press and exhibitors, it may be conservatively estimated that more than 5000 persons attended some phase of the second Atlanta meeting.

AAAS Science Theatre. The Science Theatre, which shows a selection of the latest foreign and domestic scientific films, was inaugurated at the Chicago meeting of 1947. It is now an established feature of the annual meetings of the Association. At Atlanta the theatre was located on the stage of the Municipal Auditorium, in proximity to the Annual Exposition of Science and Industry, but screened from the exhibit area by a heavy velvet curtain. It was reached by passing through the exhibits. For the seven programs given during the week, the 300 chairs were well filled by ever-changing audiences. Many came to see a particular film and stayed for several more. The 39 different films as listed in the General Program Directory were shown, in most cases, more than once. To these were added the following films received later: *Smog,* Air Pollution Foundation, Los Angeles, California; *The Golden Leaf,* American Tobacco Company; *Mining For Nickel,* International Nickel Company, Inc.; and *The Rocket,* British Information Services. The Association again expresses its appreciation to those who so kindly lent such excellent subjects.

Annual Exposition of Science and Industry. The 1955 Annual Exposition of Science and Industry filled the large horseshoe-shaped arena of the Municipal Auditorium. In most cases, the exhibitors were pleased with the interest shown by the attendance. Because of a scheduled athletic event in the evening of 23 Dec. and the holidays, the erection of booths by the Shepard Decorating Company did

Table 2. Attendance by subject fields.

Subject field	Paid registrants	Complimentary admissions to exhibits
Mathematics and statistics	35	14
Physical sciences		
Physics	129	160
Meteorology	23	0
Astronomy	16	59
Chemistry	146	76
Geology and geography	61	17
Engineering and industrial science	56	176
Biological sciences		
Plant pathology and mycology	394	4
Other botanical sciences	98	5
Ecology and limnology	37	0
Genetics and cytology	36	2
Microbiology	21	0
Parasitology	179	2
Zoological sciences	210	17
Biology (in general, and other)	193	47
Agricultural sciences	66	19
Medical sciences		
Bacteriology and virology	21	4
Biochemistry and nutrition	72	3
Physiology	53	1
Psychiatry	30	1
Dental research	22	2
Pharmacy and pharmacology	51	3
Medicine (in general, and other)	106	72
Psychology	94	18
Economic and social sciences	19	30
History and philosophy of science	25	10
Science teaching and education	138	70
Scientific editorial problems	42	0
General interest in science	87	625
No field indicated	176	97
Total	2636	1534

not begin until early on the morning of 26 Dec. By noontime, however, it was possible for many of the exhibitors to begin installation of their exhibits. In the arena, there were 92 booths; in nearby Taft Hall, the Embassy of Israel presented for the first time in this country an exhibit of the work of the leading scientific institutions in Israel; this exhibit occupied space equivalent to that of 30 booths.

The names of most of the 66 exhibitors and descriptions of their exhibits appeared both in the General Program-Directory and in the preconvention issue of *Science*. Those that did not are listed here: American Red Cross, Georgia Chapter; Atlanta Publishing Company; Communicable Disease Center, USPHS, Computer Center, Georgia Institute of Technology; Georgia Power Company; Georgia State Department of Public Health; International Geophysical Year; National Cancer Institute; J. C. Nichols (living salamanders); Southern Bell Telephone and Telegraph Company; United Nations.

The Science Library had some 500 volumes from 37 publishers. As in past years, the Association is indebted to the Special Libraries Association, this time the Georgia Chapter, for supervising the Science Library.

Work of the Atlanta committees. The Association and all who attended the 122nd Meeting are much indebted for the excellent appointments and wise counsel of James V. Carmichael, president of Scripto, Incorporated, and general chairman of the Atlanta meeting who had kept in close touch with all developments since the spring of 1954. Until the last minute, when it proved impossible, he had expected to be present at the AAAS presidential address and reception. His place there and at the opening ceremonies of the Embassy of Israel exhibit was filled by the general vice chairman, Robert S. Lynch, president, Atlantic Steel Company. Bradford D. Ansley, of the Trustees Committee on Development, Emory University, served as executive secretary of the Atlanta committees. Despite his many professional duties, he devoted considerable time to coordinating local activities and solving problems as they arose, ably assisted by his secretary, Anne Cain.

The Atlanta Committee on Physical Arrangements, headed by Walter S. Bell of the department of audio visual education, Atlanta Board of Education, proved to be one of the most efficient, hard-working, and economical committees responsible for projection and other equipment that the Association has ever had. Not only did Bell and his colleagues supply every lantern, screen, and volunteer operator requested, and check the chairing and darkening of each room, but they took care of the Science Theatre and stood by for emergency requests for anything from a thumbtack to a tape recorder, complete with operator and typist. The Association gratefully acknowledges the work of this committee.

The local committee on public information, composed of 14 members, was headed by George C. Biggers, Sr., president of Atlanta Newspapers, Inc. The work of this committee contributed greatly to the wide coverage by press, radio, and television given to the events of the annual meeting. An attractive window display on atomic energy and a welcome to AAAS delegates were suggested by Julian Trivers, vice president, the Davison-Paxon Company.

The Exhibits Committee, under the chairmanship of D. J. Haughton, vice president and general manager, Lockheed Aircraft Corporation, Georgia Division, canvassed local and regional industry and secured exhibitors that otherwise would not have been present. The Association is particularly indebted to R. R. Kearton, assistant general manager of Lockheed, who devoted considerable personal time and thought to this phase of the financing of the meeting. The members of the Finance Committee, with Fred J. Turner, president, Southern Bell Telephone and Telegraph Company, as chairman, helped greatly to reduce the deficit of the meeting. Firms that endowed booth space for nonprofit exhibits or made outright contributions include:

American Bakeries Company
Associated Industries of Georgia
Atlanta Coca-Cola Bottling Company
Atlanta Envelope Company
Atlanta Stove Works
Atlanta Transit System
Atlanta Steel Company
Auto-Soler Company
Barge-Thompson Company
Cabin Crafts, Inc.
Chicopee Mills, Inc.
Citizens & Southern National Bank
Colonial Stores, Inc.
Cotton Manufacturers Association of Georgia
Embassy of Israel
First National Bank of Atlanta
Fulton National Bank
Ford Motor Company, Atlanta Assembly Plant
George Muse Clothing Company
Georgia Power Company
Georgia State Chamber of Commerce
Georgia State College of Business Administration
Gulf Oil Corporation, Atlanta Sales Division
Ivan Allen Company, Office Equipment
Irvindale Dairies

MacDougald-Warren, Inc.
Merrill Lynch, Pierce, Fenner, & Beane
Plantation Pipe Line Company
Rich's, Inc.
Scripto, Incorporated
Sears, Roebuck and Company
Southern Bell Telephone and Telegraph Company
The Bank of Georgia
Trust Company of Georgia

To these should be added a contribution made for the third time by the United-Carr Fastener Corporation of Cambridge, Mass., to the AAAS for any worthy purpose and applied to the second Atlanta meeting.

Walter E. Crawford, executive vice president of the Atlanta Convention Bureau, provided much personal assistance and friendly help prior to, and throughout, the meeting.

To all those named, and to those who volunteered their services for clerical assistance in the AAAS office in the Municipal Auditorium, and to all who made contributions, the Association expresses its deep appreciation. The whole experience in Atlanta with so many courtesies and instances of cooperation was a heart-warming and memorable one.

Awards and prize winners. The following annual awards were made at the meeting: 28th AAAS Newcomb Cleveland prize, to Seymour S. Cohen, professor of biochemistry, University of Pennsylvania, for his paper, "Metabolic changes in virus infections," read before Section N–Medical Sciences; 11th AAAS Theobald Smith Award in the Medical Sciences to Robert A. Good, American Legion heart research professor, University of Minnesota Medical School, for his work in hematology and immunology; 1st AAAS–Anne Frankel Rosenthal Memorial Award for Cancer Research to Lloyd W. Law, laboratory of biology, National Cancer Institute, for his studies on leukemia and chemotherapy; 2nd AAAS Socio-Psychological prize, to Yehudi A. Cohen, department of psychiatry, Albert Einstein College of Medicine, for his manuscript, "Food and its vicissitudes: a cross-cultural study of of sharing and nonsharing in 60 folk societies"; Scientific Research Society of America–William Procter prize, to Robert R. Williams, chairman, Williams-Waterman Fund for the Combat of Dietary Diseases, Research Corporation, presented after his address, "Chemistry as a supplement to agriculture in meeting world food problems"; John Scott award, administered by City of Philadelphia Board of Directors of City Trusts, to Edgar S. McFadden, agronomist, Texas Agricultural Experiment Station, for his origination and development of the first rust-resistant bread wheat, presented under the auspices of Section O during the "Atomic energy and agriculture" symposium.

RAYMOND L. TAYLOR
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Unusual Fish

The cover this month is a photograph of a male sea horse, which is carrying eggs in the pouch that bulges out to the right of the tail. The eggs, which may number several hundred, are laid in the pouch by the female and are carried by the male until they hatch as minute replicas of their parents. In some species of sea horse, the newly hatched fry, on their first emergence from the pouch, hover about their father and swim—one is tempted to say scamper—back into the safety of the pouch at the slightest sign of disturbance. Sea horses are unusual among bony fishes in other ways. The head is movable instead of fixed; the swimming posture is upright (as is shown in the photograph) instead of horizontal; propulsion is by the dorsal fin instead of by sinuous movements of body and tail; and, what is perhaps most remarkable, the tail is prehensile and is used to grasp the sea weeds among which the animal lives. The photograph was taken by A. M. Winchester, Stetson University.